Architectural Concrete *for* SMALL BUILDINGS

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Fig. 1. U. S. Post Office, Stephenville, Texas. Mark Lemmon, architect, Dallas; Lundburg and Richter, contractors, Liberal, Kansas.

"The building shall not depend for its impressiveness upon anything that is perishable."—Ruskin

FOREWORD

Careful planning, attractive design and workmanlike construction are essential in the small store, factory or village fire station just as they are in a monumental post office or large city school. Simply because a building is small is no reason why it should just grow up like Topsy.

The Main Streets of the country are largely made up of one and two-story buildings housing but a single commercial or industrial enterprise. Individually they may not seem important nor of concern to others than the owner or occupants, but collectively they make the tiny village, the middle-size town and the big city. The appearance of the whole community depends upon the separate units which constitute it.

Aside from individual and civic pride in the fine appearance of one's property or community there is the more mundane but equally important consideration of the investment value of the well-built, permanent, attractive building. Customers are drawn to the store that looks inviting, to the bank that reflects its sound conservative policy in the substantial appearance of its place of business, and even the corner gas station that radiates efficient service in every line of the structure attracts trade from the less pleasing establishment across the corner. Moreover, the initial cost of such buildings is often no greater than that of their less attractive neighbors and, when constructed of durable firesafe materials properly used, the maintenance and insurance costs that go on throughout the life of a building may be reduced to a minimum.

This booklet is written to assist the building profession and owners to secure full value from the use of architectural concrete in small buildings by presenting a few examples and offering some suggestions about the use of the material.

Portland Cement Association

Architectural Concrete For Small Buildings

SECTION I—ARCHITECTURAL DESIGN

MUCH has been written on the fundamental principles of architectural design. It is not intended in this booklet to enlarge upon or even discuss the application of those principles to buildings in which concrete is the architectural medium. As far as design fundamentals are concerned, there is no essential difference between the concrete building and buildings constructed of other materials. It is true that one material may give greater freedom to the designer to exercise his imagination than does another material which may have structural limitations or limitations of form and texture. But, in the sense that architectural design involves consideration of purpose and function, mass and line, rhythm and harmony, the problem presented by the architectural concrete building is in no way unique.

There is likewise no vast difference between the design of a small building and a large one. In the broad sense, architecture embodies and makes use of most of the fine arts and many sciences, combining them into a physical structure that meets the practical demands of supporting loads and affording shelter while satisfying certain esthetic requirements. Obviously, if the small building is to be pleasing to the eye, is to fulfill the requirements of good architecture, then the same application of the arts and sciences must be made as in the design of more pretentious buildings.

Primarily it is in the details that architectural concrete differs from other materials. How to obtain desired form, texture and color; what can be done most appropriately, readily and economically? It is in the answers to these questions that the designer is vitally concerned with the architectural medium, so that which follows will be devoted only to those details influenced by the use of concrete as a finish material.

Fig. 2. Radio transmitter station KFPY, Spokane, Washington. Rigg and Vantyne, architects; Alloway and Georg, contractors.

Surface

Whether a building is constructed of brick, stone, terra cotta or concrete, the surface characteristics of the material have a pronounced influence on the designer's conception of how the structure should appear. Having visualized the lines, proportions and masses of the building, translation of the mental picture into a satisfying reality requires a surface in harmony with the conceived design. The rough, coarse, rugged texture suitable for a building of large scale and normally viewed from a distance would obviously be out of keeping with a ladies' apparel shop or beauty salon done in delicate detail and situated at the sidewalk line.

A variety of textures ranging from a perfectly smooth surface without joint lines and no trace of the nature of the forming material, to the roughest texture showing an exaggerated impression of the grain of the form lumber, is possible in architectural concrete. If the texture selected is in harmony with the design, then it will look well whether smooth, rough or between the two extremes. The designer should be familiar with the variety of textures possible and just how he may expect them to appear in the finished job.

Some of the many possible surface textures in architectural concrete are illustrated and the methods of producing them are briefly described in Figs. 3 to 6*. While the number of types of surface finish is limited only by the inventiveness of the architect and the skill of the con-

*References will be made in footnotes and throughout this booklet to other publications issued by the Portland Cement Association containing additional pertinent information which will be sent free upon request. Additional textures are shown and described in "*Concrete Information—Textures—AC 11.*"

Fig. 3. Board-marked surfaces, painted and unpainted, offer a wide variety of textures from which to select the most appropriate for the style of architecture being considered. Three such textures are shown: (a) formed with vertical grain square-edged fir boards uniformly sized for thickness; (b) a slightly rougher texture produced with the same kind of lumber except boards of various thicknesses were selected to accentuate the jointing; (c) surface showing characteristic grain marking and occasional impression of knots left by square-edged yellow pine boards. The right-hand side of each picture shows the surface after applying two coats of cement paint. Smoother textures, but still showing faint traces of the joint lines between the sheathing boards, are obtained by using dressed and matched lumber.

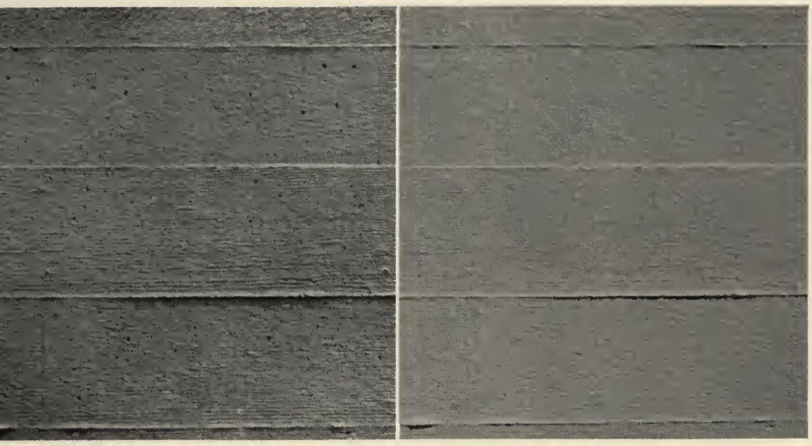


Fig. 3 (a)

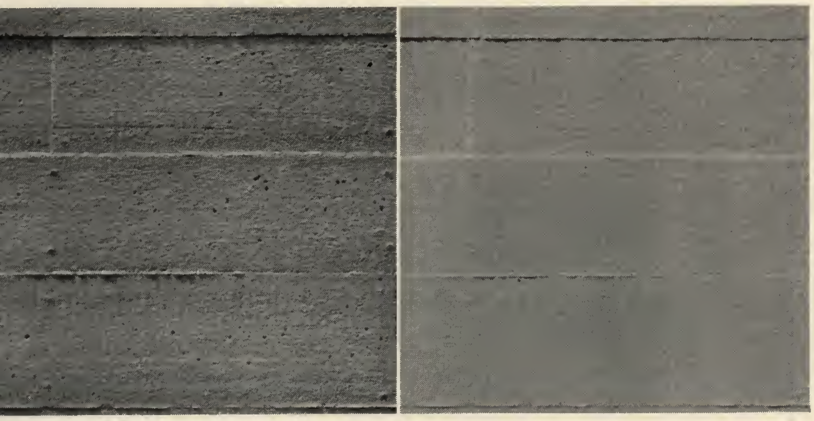


Fig. 3 (b)

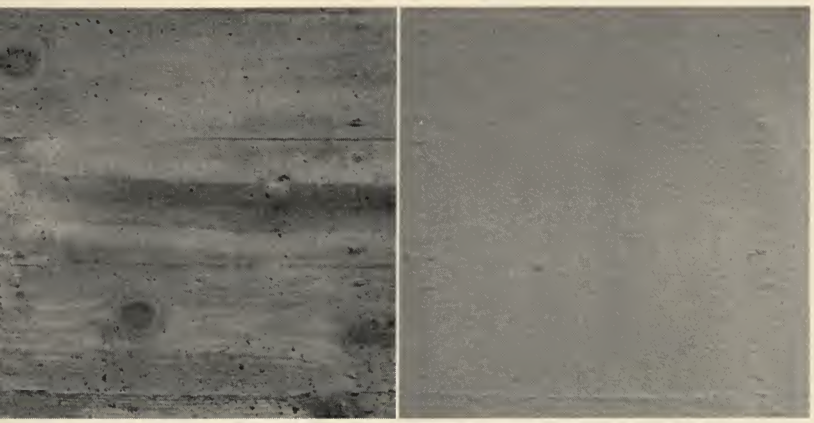


Fig. 3 (c)

tractor to find a means to execute the design, unusual or "trick" finishes should be avoided. Standard surfaces made with ordinary form boards, plywood or Presdwood and left in the natural finish revealed when the forms are stripped are suitable for most architectural styles. The surface may also be painted where a color other than that of natural concrete is desired or a light stucco spatter dash may be applied.

There is no objection to a rubbed finish when an absolutely smooth surface is desired, but the work must be properly done. It is not good practice to work up a thick paste on the surface which is left there, and allow it to dry. Even though this finely ground material is kept wet to allow it to reset, crazing and subsequent scaling may result. The paste that is worked up on the surface must be removed as described in the caption of Fig. 5, leaving only a very thin film on the surface.

Regardless of the surface texture chosen, it is advisable to construct a demonstration panel using a part of the basement wall or some other unexposed wall to determine definitely that the selected surface is just what is desired, and that the contractor is executing it properly. Such a demonstration panel should be constructed in every detail exactly the same as the exposed walls above grade will be built. Not only should the forms be the same but the concrete should be of the same mix and consistency. The place to experiment is below grade—not above.

Construction Joints

The technique of construction should always be taken into consideration in the design of any building, regardless of the building material. Just as the mortar joints and brick courses in a brick masonry building are an

Fig. 4. Rubbed surfaces present several additional textures having various degrees of smoothness: (a) slightly sandy texture produced by rubbing a thoroughly wetted concrete wall with a wood float one day after placing; (b) smoother finish produced by rubbing a dry wall with fine abrasive stone after concrete has thoroughly hardened. The right-hand side of each picture shows the surface after applying two coats of cement paint

Fig. 4 (a)

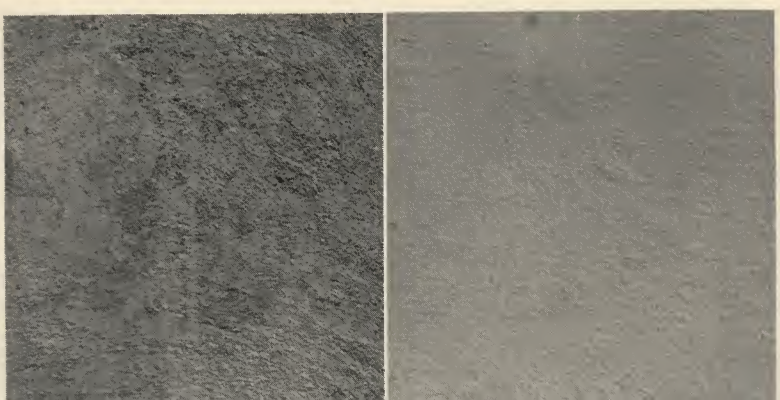
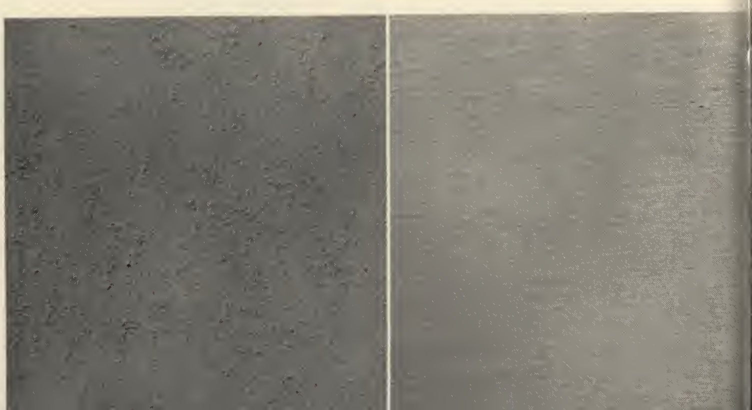


Fig. 4 (b)



a ↑ b ↑ c ↑ d ↑ e ↑

Fig. 5. The stages in the finishing of a wet rubbed wall are illustrated: (a) tie rod holes are being plugged with cement and sand mortar forced into the holes with a grease gun; (b) rubbing the concrete with abrasive stone, keeping the wall wet during the rubbing process; (c) paste worked up on surface during rubbing is largely scraped off with edge of steel trowel; (d) remaining paste is spread evenly with a wood float; (e) before paste has thoroughly hardened, surface is rubbed with burlap pad to insure smooth, even texture.

inevitable part of that type of structure and are taken into account in the layout of fenestration and other details, so are the construction joints in an architectural concrete building an essential part of the construction. The concrete in walls of only the smallest building can be placed in one continuous operation. Almost always it is necessary to provide horizontal construction joints, and occasionally vertical joints will be needed.

Since construction joints are inevitable they should be taken into consideration in the design and should be definitely located on the drawings by the architect, and no change should be made without his approval. When locating joints, a reasonable placing rate should be considered, generally not to exceed 2 feet an hour and a lift of about 6 feet between joints should be a maximum. As a rule, convenient locations for joints will be at the water table, at the window sills and heads and occasionally at the floor levels, although the latter is not so desirable, especially if the spandrels are to be left with a smooth surface.

Although construction joints, when properly made, will be practically invisible even in a plain surface, it is advisable to provide some detail that will obscure their presence. Horizontal joints are very easily obscured by rustications, belt courses and reveals. Joints at the heads and sills of windows are generally quite inconspicuous even though the wall surface between openings is plain, because the joints are broken into short sections.*

Vertical joints are not required as a rule in small buildings unless they are quite rambling, making it desirable to construct one portion at a time. If there is need for such joints to facilitate construction, they should be located at a re-entrant angle, a reveal, or at the edge of a pilaster. Sometimes a decorative panel can be provided to obscure a vertical joint if there is no convenient angle in which it can be located.

* For form details and other important suggestions regarding job practice see "*Concrete Information—Construction Joints—AC 19.*"

Fig. 6 (a) *Fig. 6 (b)*

Fig. 6. Plywood and Presdwood used as form sheathing where smooth texture and widely-spaced joints are desired. (a) A faint trace of the grain of plywood is left in the concrete, which is preferred by many. Painting will cover the grain impression, if objectionable, as it is a difference in color rather than a roughness of surface. Joints between panels are made quite inconspicuous by pointing with a mixture of equal parts of tallow and cement. (b) Presdwood-formed surfaces show no texture, which is desired for some architectural styles. A tight board sheathing is required as a backing for Presdwood which is applied as a lining. Sheathing lumber need not be as good a grade as for a contact surface, but should be uniformly sized so no impression of the backing will show in the finished surface.

Spandrels

The spandrels in a building are important elements in the architectural design. They afford an opportunity for decorative treatment, and proper detailing will do much to enhance the appearance of the building. As noted in the discussion of construction joints, it is sometimes necessary to locate a joint at the floor level, which will often be about the mid-height of the spandrel. Under such circumstances it is highly desirable to provide some horizontal architectural detail at that level at which to stop the placing of concrete. If this can not be done conveniently, an ornamented spandrel in which the otherwise plain surface is broken up into a design or pattern will aid greatly to make the joint inconspicuous by providing a play of light and shadow.

In urban communities it is inevitable that the moisture which collects on windows will trickle down over sills laden with soft coal soot. This dirty water will then run down over the spandrel below. It is not the water that rushes down the window pane during a hard rain that causes streaking and discoloration of the wall surface, but these small trickles of soot-laden moisture. While this natural aging and discoloration is not considered by many to be detrimental to the appearance of the building, others prefer to prevent it if possible or to make it less noticeable by some device.

Projected window sills will help prevent moisture streaking to some extent by causing the trickles of water to drip free of the wall. The nose of the sill should, of course, be provided with a drip. Sills of this type may be precast and set after the rest of the wall is completed, or they may be cast in place after the concrete in the spandrels and jambs has hardened.*

When flush sills are used or even with projected sills, apparent discoloration can be minimized readily in architectural concrete by taking advantage of light and shadow. For example, a spandrel with vertical flutes will not appear to be discolored by water streaks, while they would be quite noticeable on a plain, smooth surface. The moisture will tend to follow the back of the flutes, which are in shadow, while the outer surface is in highlight. Any kind of decoration that breaks the surface into a pattern of raised and incised areas will create a design of light and shadow that will obscure moisture streaking.**

Fig. 7. This unit of Safeway Stores, Inc., Spokane, Wash., designed by Rigg and Vantyne, architects, and constructed by Peter Young, has walls resembling clapboard siding. The effect was produced by overlapping the 8-in.-wide sheathing boards. Walls are finished with buff-colored cement paint, while fluting in pilasters is accentuated with a contrasting color.

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* See "*Concrete Information—Windows—AC 6.*"

** See "*Concrete Information—Spandrels—AC 9*" for additional illustrations and construction details.

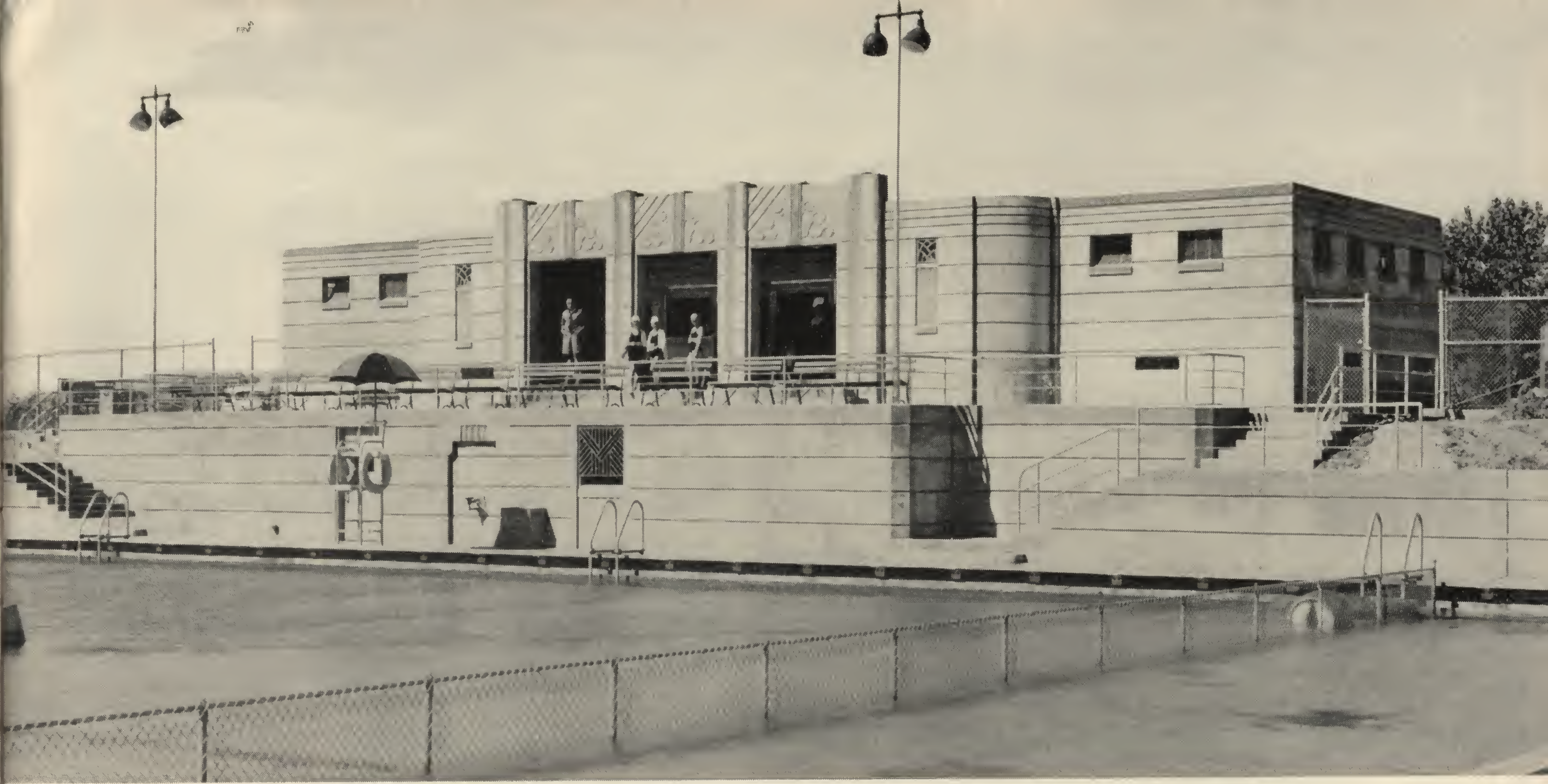

Fig. 8. Concrete just as it came from the forms was desired by the architects, McClure and Walker, for the municipal bath house, Kearney, Neb., so Contractor Henry Knutzen did not touch the surface of the walls to remove any slight variations in color or to grind off minor imperfections. Conveniently-placed rustications obscured the position of construction joints.

Ornament

Ornament may enhance or detract from the appearance of a building. Architectural concrete gives the designer great freedom in the use of ornament because almost any conceived design can be executed. The very fact that ornamental detail can be constructed so readily in concrete may lead to over-indulgence, which is to be avoided. Usually restrained ornament that can be executed with simple wood molds will be the most appropriate for small buildings.

Consideration should be given in the design to the type of ornament that can be constructed most readily, which usually means most economically. It is a good general rule to incise ornament rather than project it. Incised ornament, that is to say, any ornament that is flush with or recessed back of the wall surface, can be formed by fastening wood strips, moldings and even plaster waste molds on the wall form without cutting an opening for the special form or mold. Projected ornament, of course, requires cutting through sheathing, studs and wales, which complicates the form construction and makes it somewhat more expensive.

Fluting offers interesting possibilities as ornament.* There are many profiles that can be formed with wood; corrugated metal makes other shapes available. The number of geometrical patterns that can be formed with combinations of square, rectangular and triangular pieces of wood attached to the surface of the wall forms is practically limitless. Floral forms and shapes involving warped surfaces and undercuts, of course, must be formed with plaster waste molds. When plaster molds are used it is well to repeat the detail several times to reduce the unit cost of the molds although a single mold, if of simple design, will not be unduly expensive.

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* See "*Concrete Information—Ornament—AC 14*," also "*Pilasters—AC 10*."

Fig. 9. The Blade-Tribune and News building, Oceanside, Calif., finished with a very thin coat of stucco troweled to a smooth surface. All detail was formed when the concrete for the walls was placed. Designed by Irving J. Gill, architect (deceased) and constructed by George W. Schmidt.

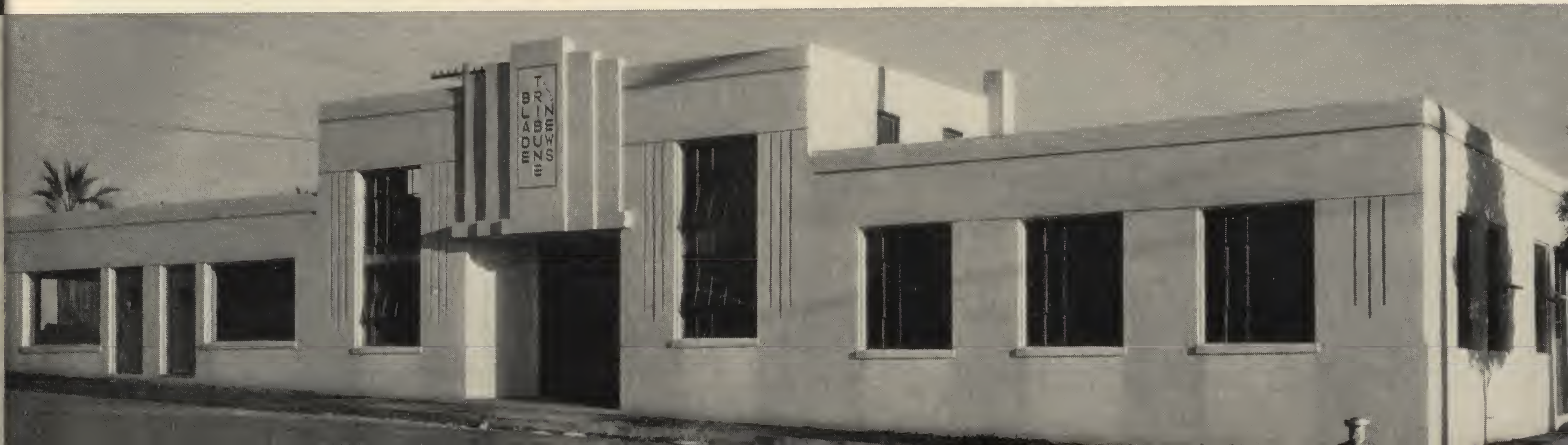


Fig. 10. Variety of textures lends interest to Shopping News building, Long Beach, Calif., designed by Miller and Gibbs, architects, and built by J. E. Burrell, contractor. Plywood with smooth joints was used for the spandrel forms, while slight irregularity of the joints between plywood panels on the parapet were permitted to produce interesting contrast. An even greater contrast is obtained by using rough-sawed sheathing with chamfered edges for the wall between spandrel and parapet. Construction joints at sill and head of windows are obscured by the projecting bands.

SECTION II—SPECIFICATIONS

SECOND only in importance to an adequate set of plans is the job specification. It is the written basis of understanding between the architect, contractor and owner as to how the construction of the job is to be carried out and what results may reasonably be expected. The provisions of a specification should be made positive and definite.

The specification for the architectural concrete work for a small building does not differ materially from that for a large structure except, perhaps, because of the size and simplicity of a certain small job all the possible types of forms may not be required for that building. On the other hand, even a small structure may involve, with entire consistency of design, unlined and lined forms, plaster waste molds and metal forms. All the requirements of good materials and careful workmanship that are essential to the large job are equally essential to the small one and they should be set forth in the specification. The principal subjects that should be included in an architectural concrete specification are discussed in the following paragraphs.

Materials

The cement should be specified to be of American manufacture conforming to the standard specifications of the American Society for Testing Materials for standard portland cement or high early strength portland cement. By requiring that the cement be delivered to the job in sacks bearing the brand and name of the manufacturer, conformity with the specification may be assured.

Fine aggregate is usually natural sand, although artificial sand made of crushed limestone is sometimes used. If the latter is permitted it should be definitely stated that the artificial sand shall be manufactured specifically as fine aggregate for concrete. Ordinary giratory crusher screenings are not satisfactory. Artificial sand must conform with the grading required for natural sand and should be considered acceptable only if a concrete of satisfactory workability can be made with it.

A uniform gradation of the fine aggregate—95 per cent of which should pass a No. 4 sieve—should be required. It is important that the fine aggregate contain

Fig. 11. Construction joints need not be conspicuous even in large, smooth areas when properly constructed. Simplicity, unmarred smooth surfaces and flowing lines characterize the Teche Greyhound Bus Depot, New Orleans. Diboll, Boettner and Kessels, architects; Caldwell Bros. and Harte, contractors.

a certain amount of material that will pass a No. 50 sieve in order to produce a workable mix and one that will not "bleed." By bleeding is meant the accumulation of water at the top of the concrete being placed, which is the cause of sand streaking. This can be prevented very largely by being sure that at least 10 per cent of the sand will pass a No. 50 sieve and preferably more, up to a maximum of 30 per cent. The specifications should also require even a small amount of material to pass the No. 100 sieve. From 3 to 7 per cent is desirable.

Crushed stone or gravel are most commonly specified as coarse aggregate for architectural concrete, although other inert materials are sometimes used. There is a mistaken idea that a rather small, coarse aggregate is needed for architectural concrete in order to produce sharp arrises and details. Such is not the case and concrete made with a coarse aggregate, all of which will pass a ¾-in. sieve, will require about ½ sack of cement more per

Fig. 12. Horizontal rustications at fairly close spacing make it possible to place concrete in relatively small quantities, which is conducive to good construction. Architects Maurer and Maurer used this device which also emphasizes the horizontality of the Long Beach Country Club, Long Beach, Indiana. Tatus and Nelson were the contractors.

Fig. 13. The small relatively unornamented building when well designed and constructed is a business asset. Typical of modern service stations that attract business is the Shell Oil Company of Canada station in Toronto, designed by R. G. Blackburn, chief engineer, and built by S. McLachlan, contractor.

cubic yard than one made with 1½-in. top-size rock to produce a concrete of the same degree of workability. This simply adds unnecessarily to the cost of the job.

For the average job it is advisable to require 95 per cent of the coarse aggregate to pass a 1½-in. sieve and be graded uniformly down to the No. 4 sieve size with not over 5 per cent passing that sieve. Some tolerance of intermediate sizes is of course necessary as, for example, a range of 35 to 70 per cent passing a ¾-in. sieve and from 10 to 30 per cent passing a ⅜-in. sieve is acceptable. Once a grading between these limits is accepted however, a greater variation than 10 per cent should never be permitted in the amount passing any sieve size, otherwise it will be very difficult to produce uniformly workable concrete.

It is usually recognized that the mixing water must be clean and free from injurious amounts of alkalies, vegetable matter and other impurities, but it is advisable to include such requirements in the job specification.

Only intermediate grade new billet steel or rail steel deformed bars or cold drawn steel wire mesh are suitable for concrete reinforcement. Sucker rods used in the oil

Fig. 14. Sumner County (Kansas) Warehouse is ornamented simply with pilasters and rustications made by nailing slightly beveled strips to the forms. Designed by Sumner County forces and built by WPA.

Fig. 15. Use was made of several types of ornament for Avon Theater, Boonville, N. Y. Fluting and interesting chevron device could be formed with wood, while medallion at top of pilasters and parapet detail would require plaster waste molds. H. G. Rice, Rome, N. Y., was the architect and C. J. Burgess the contractor.

fields, chicken wire, and similar substitutes should never be accepted under any conditions. The specifications should definitely require reinforcement bars or mesh to conform to the standard specifications of the American Society for Testing Materials.

Storage of Materials

The storage of materials is generally not a very serious problem on the small job because the quantities involved are not great. There is sometimes an inclination, however, because the quantities are small, to be careless about protecting the cement from moisture and allowing the aggregates to become dirty. Cement undamaged by premature wetting and clean aggregate are essential for good quality concrete. The specification should require adequate protection.

Forms

The perfection of the finished concrete surface and details is the criterion of the quality of job and as the

Fig. 16. Fluted pilasters contrast with the horizontal lines of the Animal Shelter, Memphis, Tenn. M. H. Furbringer, architect; M. G. Ehrman, associate—WPA project.

Fig. 17. Modern as the radio is the transmitter station for KGQ, Spokane County, Wash., built by Alloway and Georg. The round, fluted corners of the building were formed with corrugated iron.

finish of the concrete and sharp details are very largely due to the character of the forms in which the concrete is placed, too much attention can not be given in writing the specification for the formwork.

In general, only No. 1 Southern yellow pine or Douglas fir dressed and matched boards should be permitted for sheathing lumber if the forms are not to be lined with plywood or Presdwood. Sometimes a rough texture surface is desired or one in which knots and flaws in the lumber are registered in the concrete. For such textures resawed square-edged No. 1 or No. 2 boards may be used.

It is not absolutely essential to specify the grade of the dimension lumber, that is, the material for studs and wales, to be used, but nothing poorer than No. 2 grade should be allowed and it will be to the best interest of the contractor to use No. 1.

It should be required that the outside form be erected first, because by so doing a more perfect job can be done, and it can be inspected before the inside form is erected to be sure all joints are properly made and pointed to prevent leakage. Leakage of forms is the worst obstacle to obtaining sharp corners.

Douglas fir plywood ⅝ in. and ¾ in. thick is very commonly used for form sheathing. Only plywood made with waterproof glue specifically for concrete formwork should be allowed. Ordinary plywood will not give a satisfactory job. The joints between adjacent sheets of plywood should be required to be backed solidly by nailing both edges to the same stud; otherwise there will be an offset joint. Close nailing, not over 8 in. apart, is essential for smooth joints.

When forms are to be lined there is an inclination to spread the backing boards some distance apart. This practice should be prohibited by the specification because it results in a wavy surface in which the impression of the sheathing boards is very noticeable. Square-edge lumber may be used for backing, but T & G or shiplap is preferable.

Form liners should not be too thin. The specifications should require at least a $\frac{3}{16}$-in. Presdwood or ¼-in. plywood lining, otherwise the joints in the backing will be noticeable in the finish surface.

Forms for ornamental detail may be made of wood or plaster and sometimes metal. If made of wood only, No. 2, or better, Idaho white pine or equal should be permitted. White pine is easily worked and as it does not swell and warp as other woods do, sharp edges of detail are less likely to be broken.

If the job involves details made of floral forms or

Fig. 18. In remodeling the Witting Clothing Store, Green Bay, Wis., architects Foeller, Shober and Berners used only simple recessed ornament on lintels and spandrels that could be constructed readily without cutting the wall form. Lines simulating mortar joints were easily formed by tacking narrow strips to the form sheathing. J. Foeller was the contractor.

Fig. 19. Fluted pilasters lend height to main building of the Sewage Disposal Plant, Vinton, Iowa. H. R. Green Co., engineer, Cedar Rapids; E. B. Spencer, contractor, Waterloo.

rounded and warped surfaces, plaster waste molds must be specified. Such molds should be required to be well reinforced with fiber and otherwise reinforced to prevent breakage.

Pointing of all joints in architectural concrete forms is important and should be required in the specifications and carefully observed by the inspector on the job. Water putty, patching plaster or a mixture of equal parts of tallow and portland cement may be specified for pointing.

Form ties can do much to make a good quality job or to ruin what otherwise would have been a good job. Too often, specifications simply require the forms to be well tied together. This is not sufficient for architectural concrete. The type of tie must be specified. Under no circumstances should wire or strap iron be permitted. The tie used should be one that will leave the smallest possible blemish on the surface and positively must leave no metal closer than 1½ in. to the surface. Ties with lugs, cones, washers and other devices to act as spreaders that leave a hole larger than ⅞ in. in diameter or a depression at the surface that can not be patched should be definitely prohibited.

Easy stripping of the forms is essential to prevent breaking corners or damaging the surface. Oiling of all forms should be required, but all excess oil should be wiped off to avoid staining the concrete.

Fig. 20. Paneled spandrels, fluted piers and small waste mold formed details in the parapet take this warehouse for the Westfield Sanitarium, Springfield, Mass., out of the class of ordinary storage buildings. John M. Gray, architect; E. J. Pinney, Jr., contractor.

Fig. 21. Simplicity of design with just enough ornamental detail make the Woolverton and Crosbie garage and sales room an attractive place to do business. Located in Long Beach, Calif., the building was designed by Schilling and Schilling, architects.

Reinforcement

It may be even more important for the small job than for the large one to be specific about the cleaning, bending and placing of reinforcement, because this work is often done by inexperienced laborers. No reinforcement should be permitted closer than 1½ in. to the surface of the concrete, and the practice of driving nails into the front form for the purpose of supporting the reinforcing in any way whatever must be prohibited.

Proportioning Concrete

Careful control of the concrete to insure uniformity of the quality, and particularly a uniform degree of workability for the conditions under which the concrete is to be placed, is especially essential for architectural concrete work. Weight measurement of the aggregates rather than volume measurement will aid greatly in securing accurate control of the concrete mixture, because variations in moisture content of the sand affect the weight but little, but materially affect the volume due to bulking. It is, therefore, advisable to require weight batching. Aside from giving more accurate control, it usually results in a saving to the contractor.

Durability of the concrete is more vital than strength in an architectural concrete job, particularly in a small building, because the stresses are low. As far as strength is concerned 7½ or 8 gallons of water per sack of cement might be used with even less than 5 sacks of cement to the yard. Such concrete, however, would not give satisfactory surfaces nor would it be sufficiently dense and

impervious for the exposure to which it is subjected. To insure adequate durability, not over $6\frac{1}{2}$ gallons of water per sack of cement and not less than $5\frac{1}{2}$ sacks of cement per cubic yard should be allowed if the building will be subject to freezing and thawing. In the south and along the west coast a half gallon more of mixing water to a sack of cement and a minimum cement content of $5\frac{1}{4}$ sacks to the cubic yard are satisfactory.

It is advisable to specify the slump of the concrete as a guide to a satisfactory degree of workability. The slump should be under 6 in. for hand placing and less than 4 in. if vibrators are used, otherwise segregation and sand streaking are likely to occur.

Placing Concrete, Curing and Cleaning

As discussed in Section I under the heading of "Surface," every job specification should require the construction complete of a portion of a basement wall or other unexposed wall as a demonstration panel using the same materials and methods of construction as will be used for exposed surfaces. This is so important in obtaining a good job that it warrants repetition. The job should not be permitted to proceed until an entirely satisfactory panel of adequate size has been constructed to serve as a criterion for the completion of the job.

Segregation of the concrete during placing, and splashing of the forms above the level of the concrete being deposited must be avoided. This is best done by requiring that the concrete be placed through an "elephant trunk" (a canvas or metal spout), particularly if the concrete must be dropped more than 3 or 4 feet.

In addition to showing the location of construction joints on the drawings the manner in which they are made should be definitely specified, because the degree of perfection of construction joints has a very important influence on the appearance of the job. To be sure of a straight, flush joint it should be specified that the concrete be floated off to a level line, and bolts should be provided about 3 in. below the joint with which the forms above can be drawn tightly against the already hardened concrete.

Curing is a most important operation in all concrete work. The strength, imperviousness and durability of concrete is to a large extent dependent upon adequate curing. Architectural concrete should be kept thoroughly wet for at least 5 days unless high early strength cement or concrete is used, when a minimum of 2 days' curing is adequate. Wet curing means soaking wet continually. The specification should definitely require it.

There should be no honeycomb, sand streaking or other imperfection in an architectural concrete job if the work is done in accordance with the specification just outlined. There will, however, be tie holes to be plugged and if there is an occasional small imperfection which the architect will permit to be patched, it should be done in strict accordance with a carefully written specification. Mortar for patching must match the color of the concrete, which will require the use of some white cement, otherwise the patch will be considerably darker than the surrounding concrete. It should be required that a test patch be made and allowed to harden and dry out to determine the proportions of the mortar that will have a satisfactory color.

Concrete surfaces, like other masonry construction, usually require cleaning as a final operation. Water streaks, slight oil stains and accumulated dirt must be removed. It should be specified that smooth surfaces be washed with a 5 to 10 per cent solution of muriatic acid. After the acid has been thoroughly washed from the

Fig. 22. Big business is often housed in one-story buildings which, when well designed and constructed like the Caterpillar Tractor Co. salesrooms in Walla Walla, Wash., enhance property values in any city. Harold E. Crawford, architect; E. Mardis, contractor.

surface, a mixture of one part cement and one part sand should be applied as a brush coat. After the grout has begun to harden slightly, but while it can still be scraped off with the edge of a steel trowel, any excess grout should be removed and in about 1 hour the wall should be rubbed vigorously with burlap to remove the grout entirely from the surface. The process is primarily a cleaning and scouring rather than a coating over of the surface. Small air bubbles or pits on the surface are filled and the wall is left with a clean, uniform appearance.

The specification for every small architectural concrete building should include the requirements discussed in the foregoing paragraphs*. They are as important to secure good results on the small job as on the large building.

* For a typical specification see "*Concrete Information—Architectural Concrete Specification—AC-1.*"

Fig. 23. Well-proportioned design and good construction combine to make even the smallest commercial buildings valuable assets to any community. The Bank, Williston, Fla., designed and built by J. B. McLeod, is an example.

Fig. 24. Garages are utilitarian structures that frequently have been sorely neglected architecturally. These views of the Oregon Motor Stages Co. bus storage terminal and office in Portland, Ore., designed by Knighton and Howell, architects, show that such buildings may be made most attractive. The close-up showing the stucco dash finish on the concrete walls shows also the workmanlike execution of all the details by O. R. Wyman, contractor.

Fig. 25. In the jail addition to the court house in Laurel, Miss., Overstreet and Town, architects in Jackson, made use of an effective ornamental motif at each side of the entrance which was readily formed with waste molds. I. C. Garber and Sons, Jackson, were the contractors.

SECTION III—CONSTRUCTION

Forms

AN architectural concrete building is no better than the forms in which the concrete is placed. When the forms are removed the quality of the job is revealed. Assuming that the concrete mix is properly designed and has been placed with care, the character of the finished job depends entirely upon the form construction.

When concrete served only as a structural material, the architect did not concern himself with the quality of the formwork, and the contractor was interested only to the point of making forms strong enough to withstand the pressure of the concrete. With an architectural concrete job, the architect should know how the forms are to be constructed and of what materials, just as he knows the texture, color and quality of the brick and the width and type of mortar joints to be used in a brick masonry job. Although the forms do not remain as a part of the finished wall, their lasting impression is left in the concrete so, in effect, the forms of an architectural concrete job are after all a component part of the finished product.

Just as it is important to build structural concrete forms

Fig. 26. A wide variety of architectural styles are found in United States Post Office buildings executed in architectural concrete. The one at Luling, Texas, was designed by the Treasury Department and built by Algernon Blair, contractor, Montgomery, Ala.

Fig. 27. The quality of food and service offered at Yaw's Top Notch Restaurant, Portland, Ore., is proclaimed by the exterior of the building which literally invites patronage. Modest but effective detail lends interest to the design made by Cash and Wolff, architects, and executed by Ward and Milbrandt, contractors.

strong enough to withstand the pressure of the concrete, it is doubly so for an architectural concrete job, because a little deflection or bulge in a column or beam may be covered up if some veneer is used, but where the concrete is to be left exposed, bulges and irregular lines cannot be tolerated. The contractor should design his forms just as any other structure is designed to carry load or resist pressure, and the architect should pass upon and approve the contractor's form details the same as shop drawings for structural steel, cut stone or any other material that must be detailed.

The contractor will find it to his advantage even on the small job to study the job and lay out an appropriate plant. Money can be saved by doing as much work as possible on the ground in a small mill set up alongside the building. This does not mean that the forms should be made into panels which are set in position to make up the wall forms. Prefabricated panels should be used only where a single panel will cover an entire surface between reveals or openings so that a joining between panels will not be necessary.

The specification should require the kind and quality of sheathing material to be used, but if it does not, the contractor should, in the interest of economy and the quality of the finished job, use only the best grade of material required for the type of surface desired. The use of second-grade lumber, or plywood or Presdwood not made specifically for concrete forms, will lead to greater rather than less cost because of few reuses, and the quality of the work will be unsatisfactory.

Craftsmanship is essential in architectural concrete form building. Lines must be level and plumb. Joints must be made tight and corners locked so there will be no movement and leakage. Stone pockets and ragged, rough arrises result from leaky forms which can be avoided by attention to well-established principles of form construction, which are the same for every job, big or little.

Careful inspection of the forms is important. The exterior face form should almost invariably be constructed first. In this way, before the reinforcing is placed and the inside form constructed, the architect can inspect the forms carefully to be sure they are constructed as desired. If there are poorly-made joints, sheathing boards with loose knots, boards that are warped and cupped, or any other imperfections apparent in the forms at this stage of the job, they should be immediately corrected because such imperfections will mar the final appearance of the building.

The subject of form construction for architectural concrete buildings has been discussed thoroughly in the booklet "*Forms for Architectural Concrete*" which can be had upon request to the Portland Cement Association. Reference should also be made to the plates on pages 22 to 35 of this booklet for illustrations of proper form details. The forms for practically every essential part of a building are shown, including forms for special decorative details.

Reinforcing

It is sometimes thought that the reinforcing required in the walls of a small building should be less in proportion to the cross-sectional area of the concrete than in a larger building. This is an entirely erroneous conception. The reinforcing provided in the walls of an architectural concrete building is for the purpose of resisting stresses created by volume changes due to temperature and shrinkage. These forces will be virtually the same, regardless of the size of the building. The table on the next page shows the minimum amount of reinforcing that should be used in any building.

It should be noted that the size and spacing of bars is dependent upon the thickness of the wall and not upon its over-all dimensions. Small bars are recommended for wall reinforcement because of the greater surface area in

proportion to the cross-sectional area, insuring the maximum bond between bars and concrete. Another advantage in using small bars is that a better distribution is possible.

TABLE I

Wall Thickness, Inches	Horizontal Reinforcement	Vertical Reinforcement
6	⅜-in. rd. at 8-in. ctrs. in center of wall	⅜-in. rd. at 8-in. ctrs. in center of wall
8	⅜-in. rd. at 6-in. ctrs. in center of wall	⅜-in. rd. at 8-in. ctrs. in center of wall
10	⅜-in. rd. at 10-in. ctrs. in both faces of wall	⅜-in. rd. at 12-in. ctrs. in both faces of wall
12	⅜-in. rd. at 8-in. ctrs. in both faces of wall	⅜-in. rd. at 12-in. ctrs. in both faces of wall

Wire mesh made especially for concrete reinforcement may be used in place of bars. Chicken wire, woven fencing and mesh of that type is not suitable for concrete reinforcement.

There are places of critical stress in a building wall which require more than the normal amount of reinforcing shown in Table I. It has been found from experience that the parapet, for example, should have about 50 per cent more reinforcing than the wall below the roof and it is especially desirable to place two or three ⅝-in. round bars completely around the parapet at the coping line.*

The top and bottom of spandrels should also be provided with two or three fairly heavy bars, whether or not required for structural strength. Likewise, the corners of openings must be specially reinforced to resist the stresses concentrated there by the presence of the hole in the wall.**

Placing reinforcing so it is securely held in position is important. This must be done without driving any nails into the outside forms or otherwise providing a fastening that would mar the finished surface. The curtains of bars can be held away from the exposed face by tying them back to the inside form. Individual bars should be securely wired together to prevent displacement while placing concrete.**

Concrete

Strength was at one time considered the principal requirement of structural concrete. It is a factor of real importance in any concrete construction, but not the most essential quality in architectural concrete. Actually, the strength required in the walls of a small building or even a large one is not particularly high. With present-day cement and modern methods of construction, adequate strength could be secured with a water-cement ratio that

* See "*Concrete Information—Parapets—AC 5.*"

** See "*Concrete Information—Reinforcing—AC 17.*"

Fig. 28. Service stations must often be located in residential sections. Attractive structures like this Shell Oil Company station in Spokane, Wash., will not be resented by neighbors. Alloway and Georg were the builders.

Fig. 29. A modest structure of modern lines depending upon grilles and rustications to relieve large areas of plain walls, the Huff Theater, Coeur d'Alene, Idaho, was designed by Bjarn Moe, architect in Seattle. George Bottler was the contractor.

would be far too high to produce a weather-resistant durable concrete. Architectural concrete must first of all be durable so it will withstand weathering.

The job specifications should require that not over 6½ gallons of mixing water be used if the building is subject to severe exposure, or 7 gallons if located in warm climates, but if the concrete is specified on a strength basis, these water-cement ratios should not be exceeded even though strength tests run high.

For structural concrete, little attention was given to the characteristics of the aggregates or to the possible difficulties involved in placing because the aggregates might be poorly graded. Under-sanded mixes were often made placeable by the addition of water. Concrete made in this way is entirely unsuitable for an architectural concrete job because the components may segregate during placing. The addition of water not only reduces the strength but increases the porosity, with resultant loss of durability. Under-sanded mixes or mixes containing an insufficient amount of fine material passing a No. 50 sieve are subject to bleeding which results in sand streaks in the surface of the wall.

The production of durable, weather-resistant architectural concrete presents no special difficulties. It simply involves the selection and use of good materials, the use of the proper amount of mixing water, careful proportioning, placing and curing.*

Furring

Concrete, like solid brick masonry, is a relatively good conductor of heat, making it necessary to fur architectural concrete walls of buildings in the north. Furring minimizes heat loss and prevents condensation of air-borne moisture.

The amount of furring required depends upon the thickness of the concrete wall and various atmospheric conditions. Tables giving the relative values of different types of furring are available.**

The application of furring to concrete walls will depend upon the type used. There are various kinds of insulating board that can be used as a form liner against which the concrete is placed. When the forms are stripped, the insulation remains bonded to the concrete and may be used as a plaster base or may be painted. If metal lath and plaster or hollow concrete masonry is used for furring, it is secured to the concrete wall with furring strips or anchors.**

* For a discussion of the fundamental principles of concrete making, see "*Concrete Information—Proportioning, Mixing, Transporting and Placing Architectural Concrete—AC 15*" and the "*Quality Concrete Guide.*"

** See "*Concrete Information—Furring for Architectural Concrete Walls, Thermal Insulation—AC 16.*"

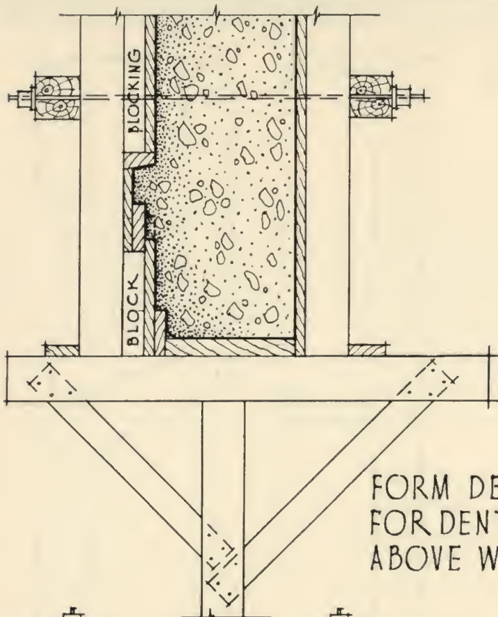
PLATES

Form Details - Layouts

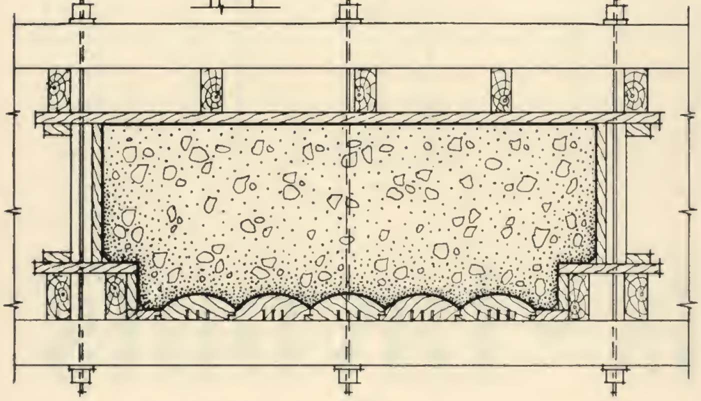
CITIZEN'S NATIONAL BANK

COMPTON, CALIF.

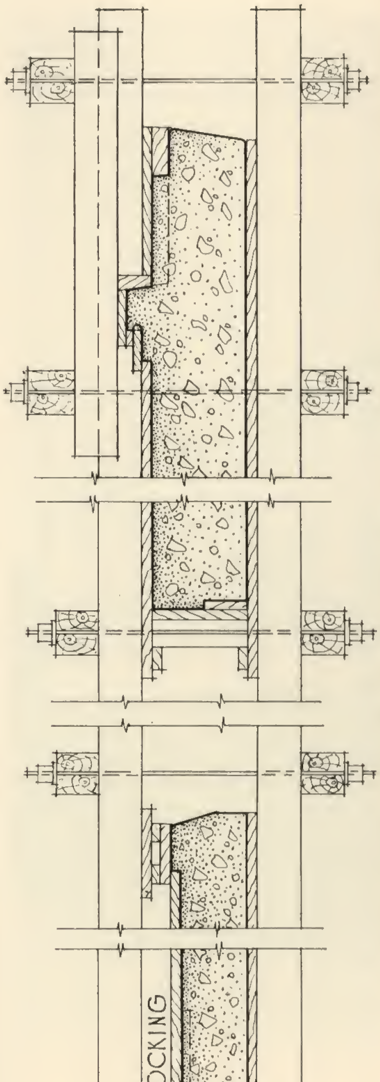
G. STANLEY WILSON, ARCHITECT
BAKKER & ROBINSON, CONTRACTORS



FORM DETAIL
FOR DENTIL COURSE
ABOVE WINDOWS



FORM DETAIL FOR
FLUTED PILASTERS

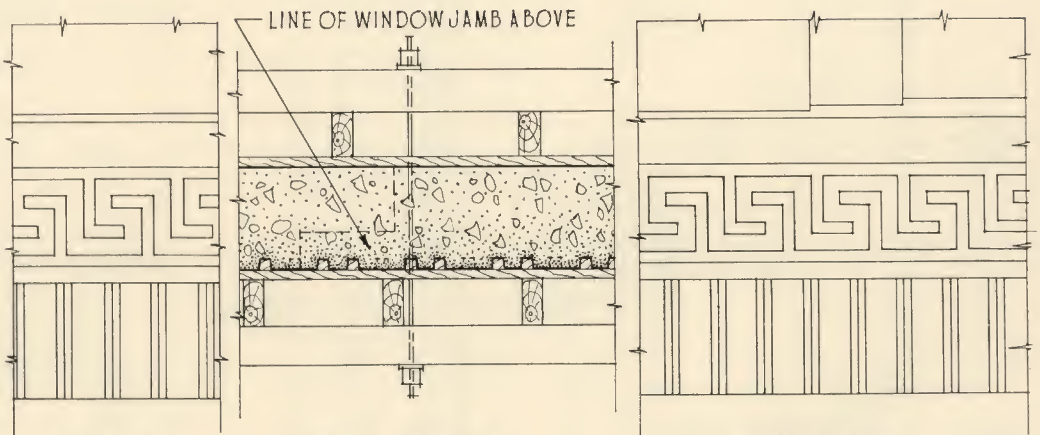


WALL SECTION
ABOVE SHOW WINDOW

DECKER BUILDING

JUNEAU, ALASKA

N. LESTER TROAST AND ASSOCIATES, ARCHITECTS
WARRACK CONSTRUCTION CO., CONTRACTOR



ELEVATION　　CROSS SECTION　　ELEVATION

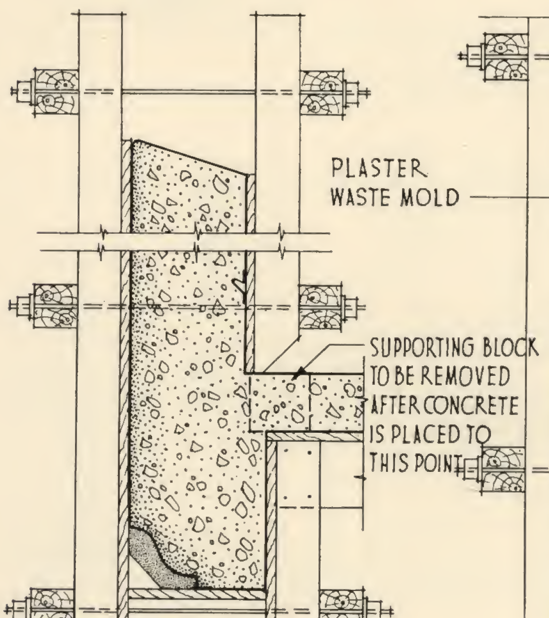
DECORATIVE BAND
ABOVE SHOW WINDOW

SUNILAND FURNITURE CO.

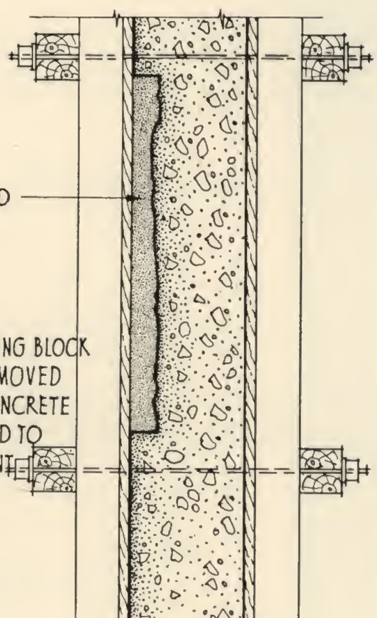
HOUSTON, TEXAS

BURNS ROENSCH, ARCHITECT

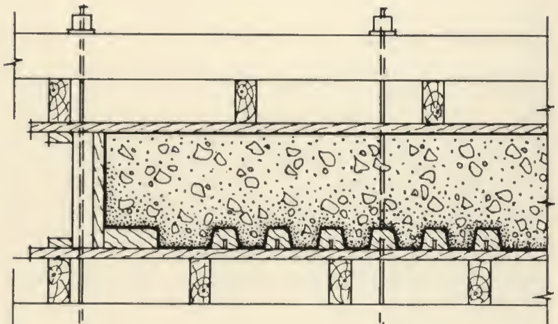
DON HALL, CONTRACTOR



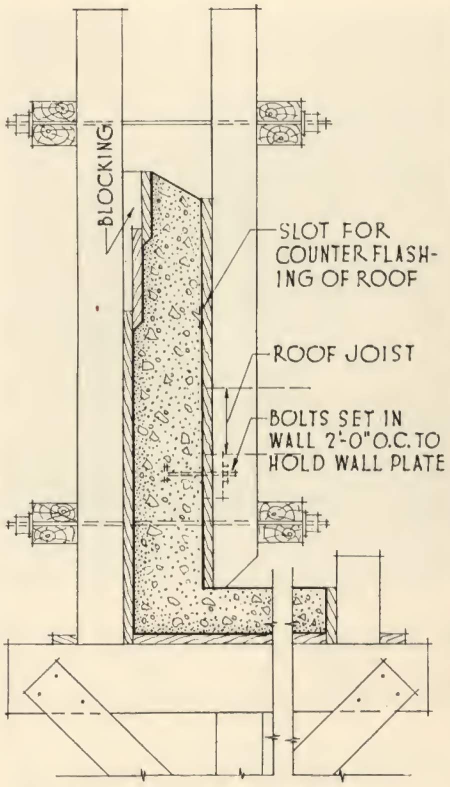
SECTION SHOWING MOULDED REVEAL-CENTER WINDOW



SECTION THRU DECORATIVE MEDALLION-ABOVE PILASTER



CROSS SECTION THRU PILASTER



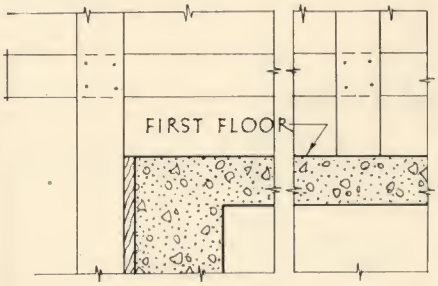
PARAPET ABOVE DOOR

SILVER CREEK RURAL SCHOOL

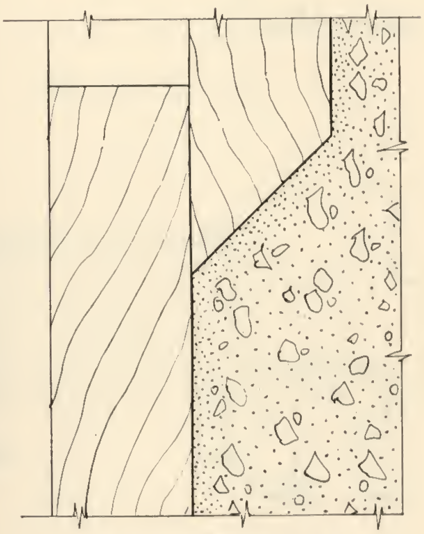
FAIRBURY, NEB.

W.P.A. PROJECT

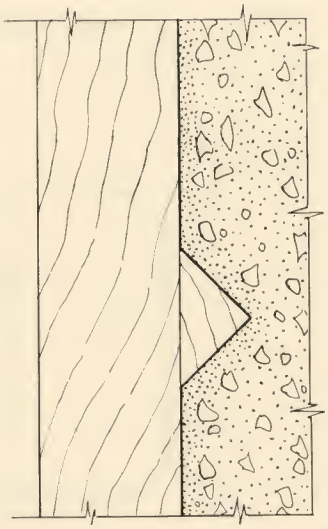
C.L. McKELLIPS, ARCHITECT



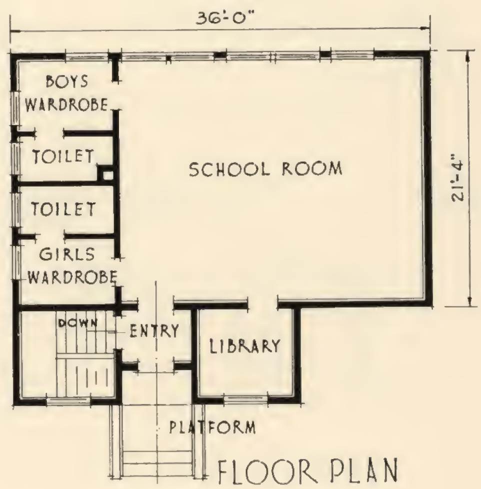
FORM DETAIL
CENTER LINE OF FRONT



FULL SIZE DETAIL
OF WATER TABLE



FULL SIZE DETAIL OF V-STRIP
AT TOP & BOTTOM OF WINDOWS



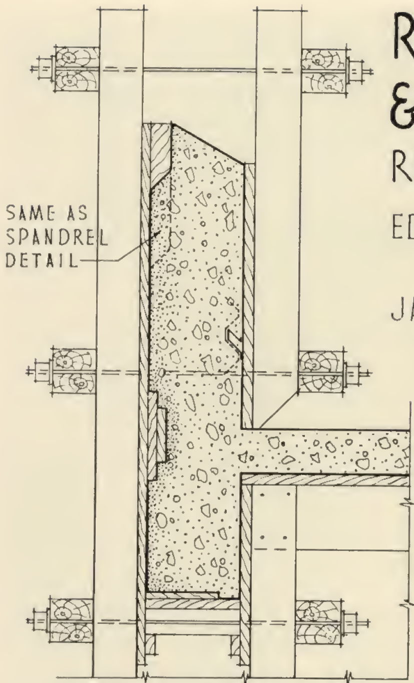
FLOOR PLAN

RICHMOND SAND & GRAVEL CORP.

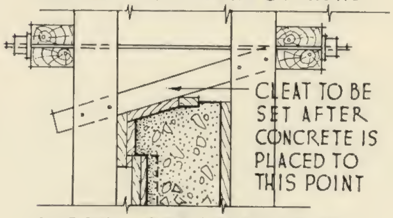
RICHMOND, VA.

EDWARD F. SINNOTT, ARCHITECT

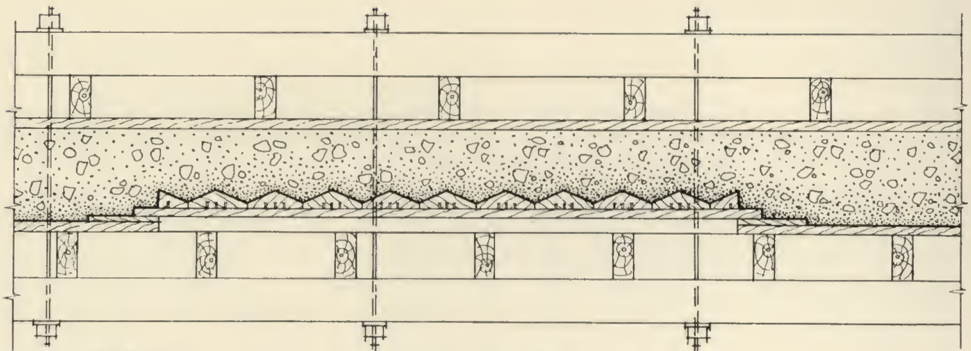
JAMES FOX & SONS CONTRACTORS



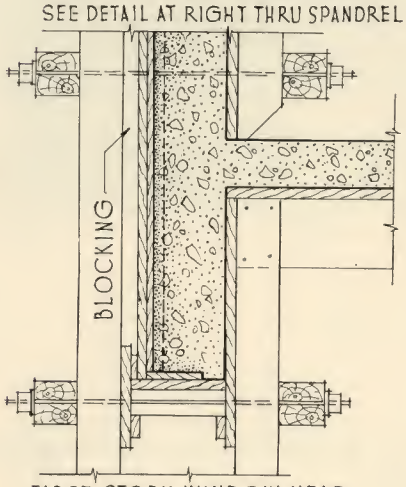
SECOND STORY WINDOW HEAD



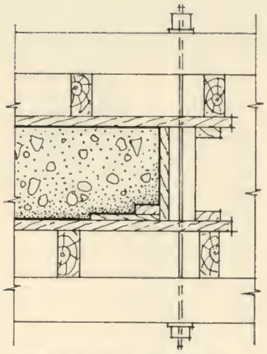
SECOND STORY WINDOW SILL
SEE DETAIL AT RIGHT THRU SPANDREL



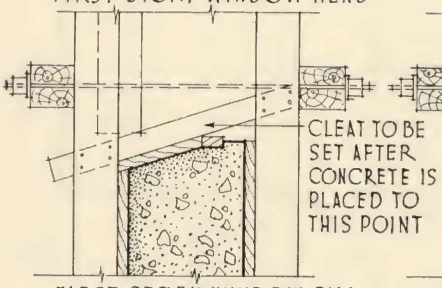
SPANDREL



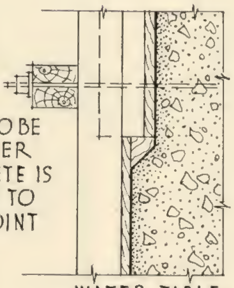
FIRST STORY WINDOW HEAD



WINDOW JAMB

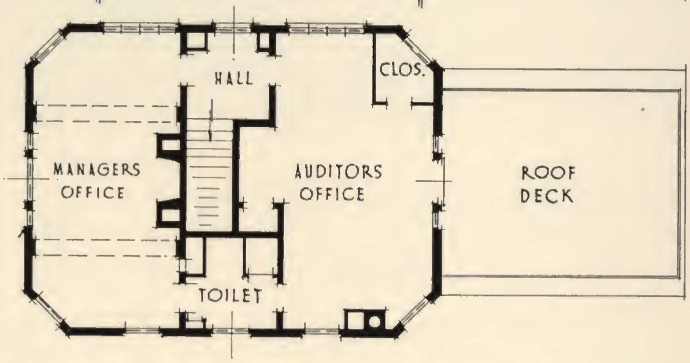


FIRST STORY WINDOW SILL

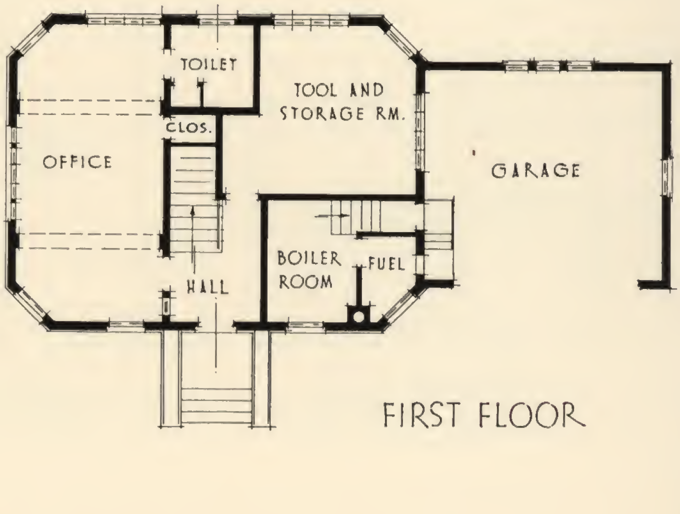


WATER TABLE

WALL FORMS



SECOND FLOOR

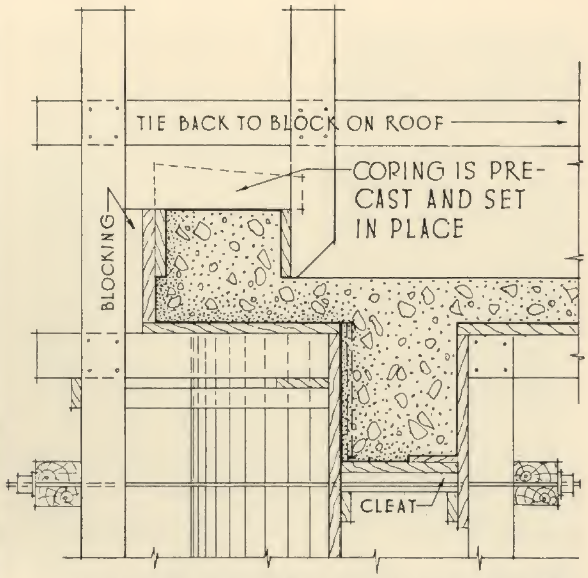


FIRST FLOOR

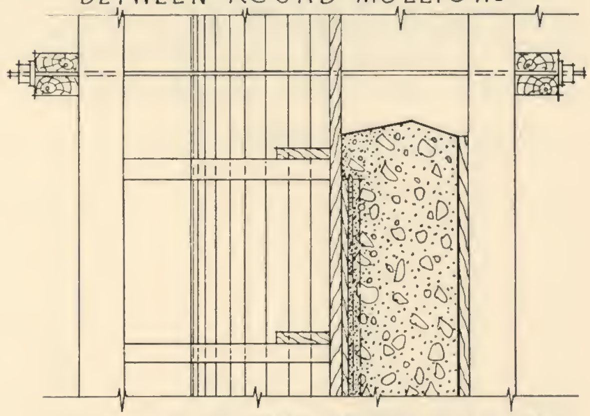
HOLMES COUNTY JAIL

LEXINGTON, MISS.

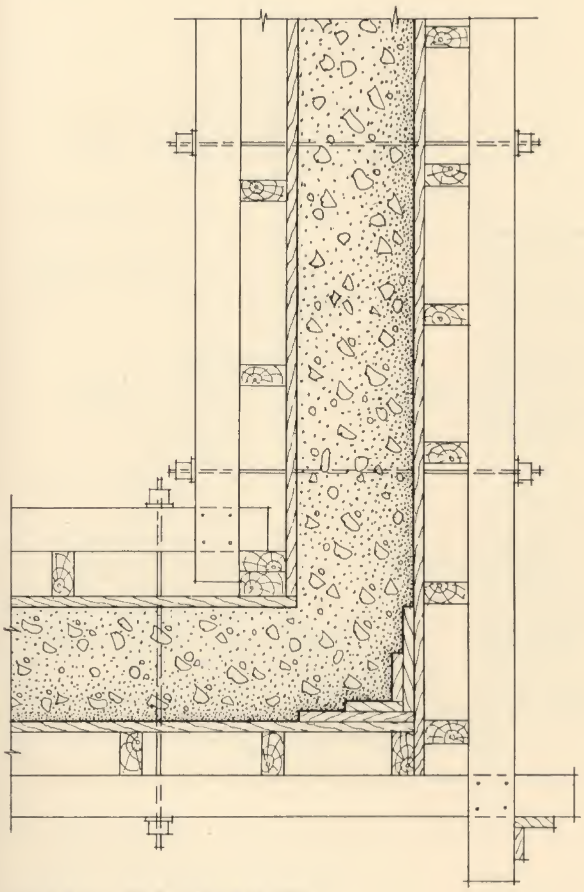
OVERSTREET AND TOWN, ARCHITECTS
CURRY AND CORLEY, CONTRACTORS



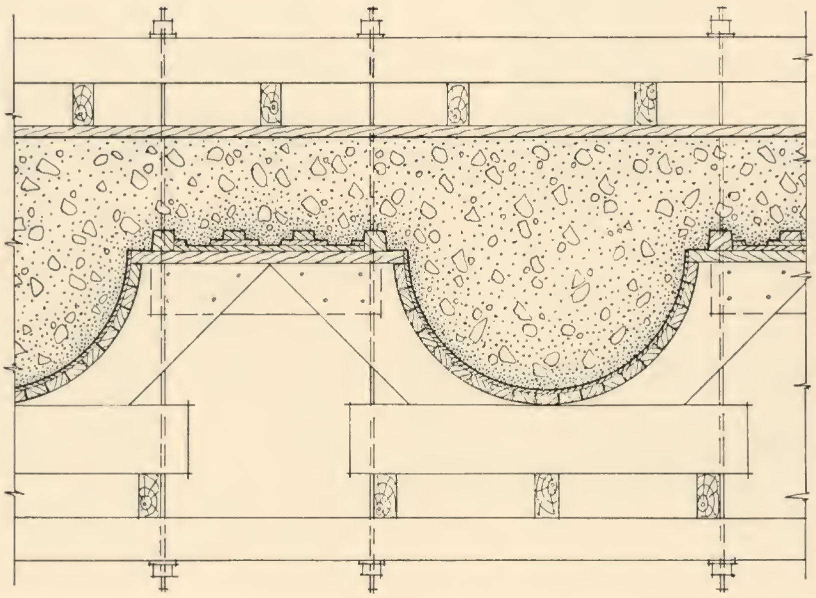
HEAD OF SECOND STORY WINDOWS BETWEEN ROUND MULLIONS



SILL OF SECOND STORY WINDOWS SHOWING ORNAMENTED SPANDREL



DETAIL OF CORNER



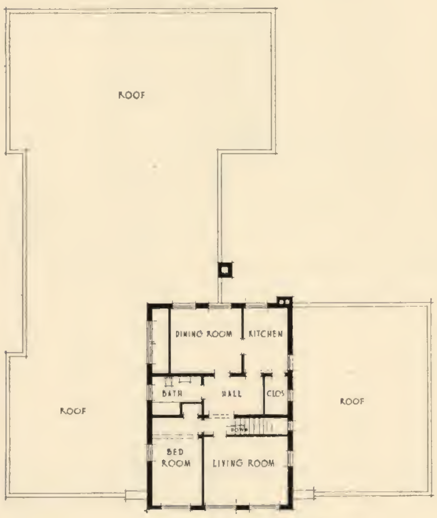
CROSS SECTION OF ROUND MULLIONS & SPANDREL

MUNICIPAL JAIL

LYNCHBURG, VA.

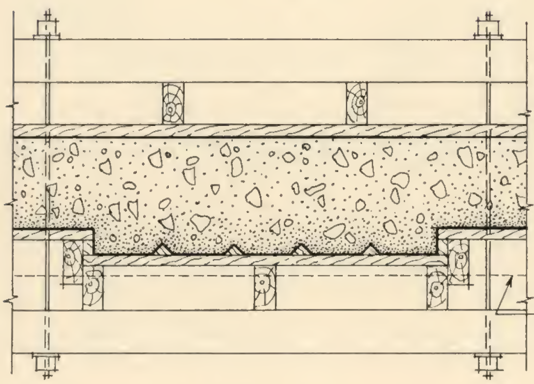
HINNANT AND SMITH, ARCHITECTS

JOHN MILLER, CONTRACTOR

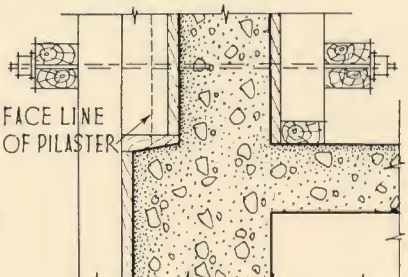


SECOND FLOOR

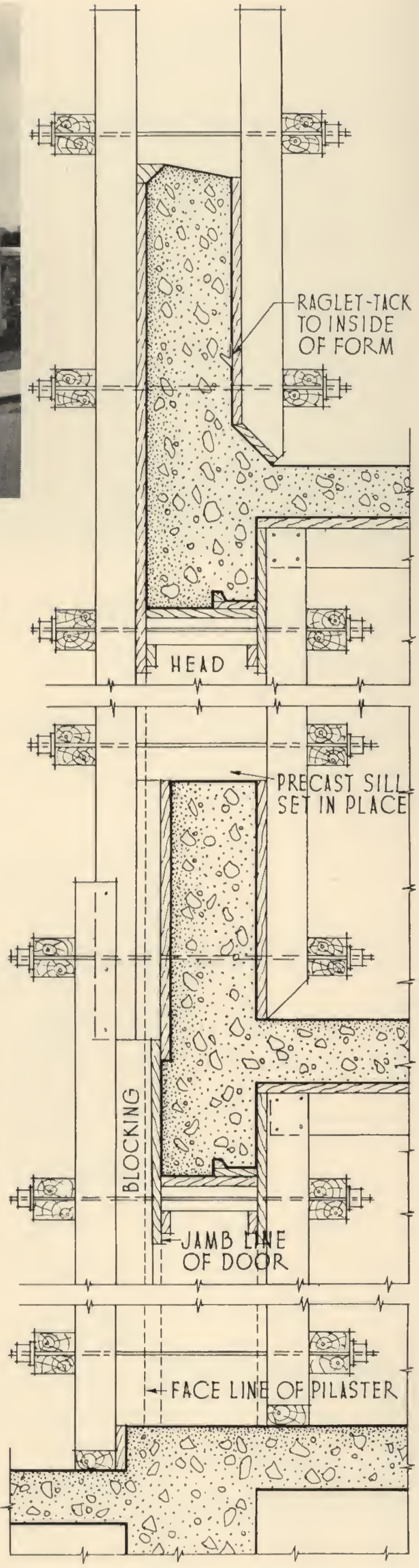
FIRST FLOOR



FORM FOR PILASTER WITH V- FLUTING



SECTION THRU WATER TABLE



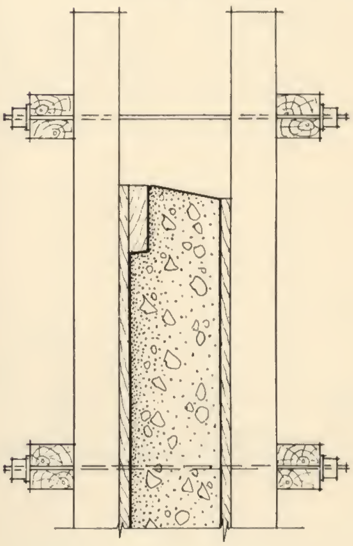
SECTION ON CENTER LINE THRU FRONT OF BUILDING

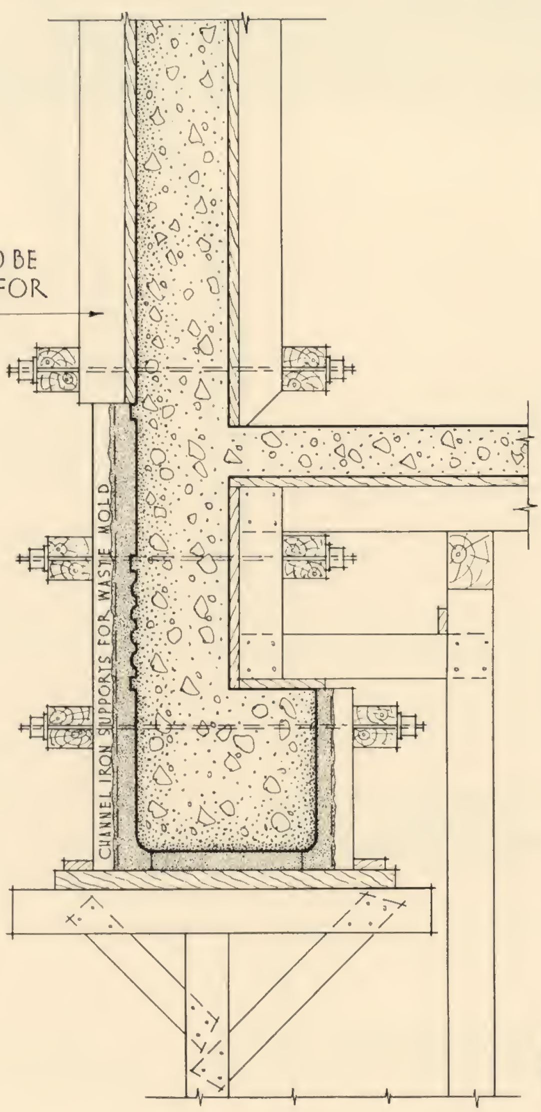
ASSOCIATED TELEPHONE COMPANY LIMITED

ONTARIO, CALIF.

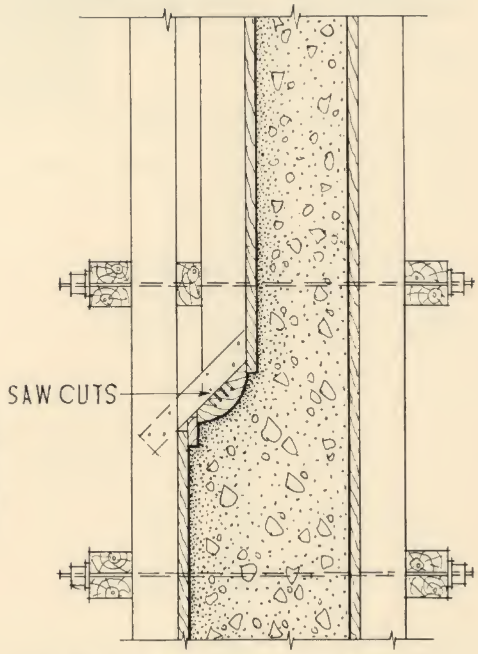
MAURICE SASSO
STRUCTURAL ENGR.

CAMPBELL CONST. CO., CONTRACTOR

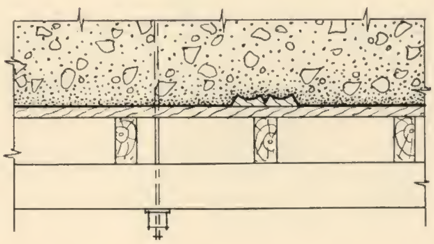




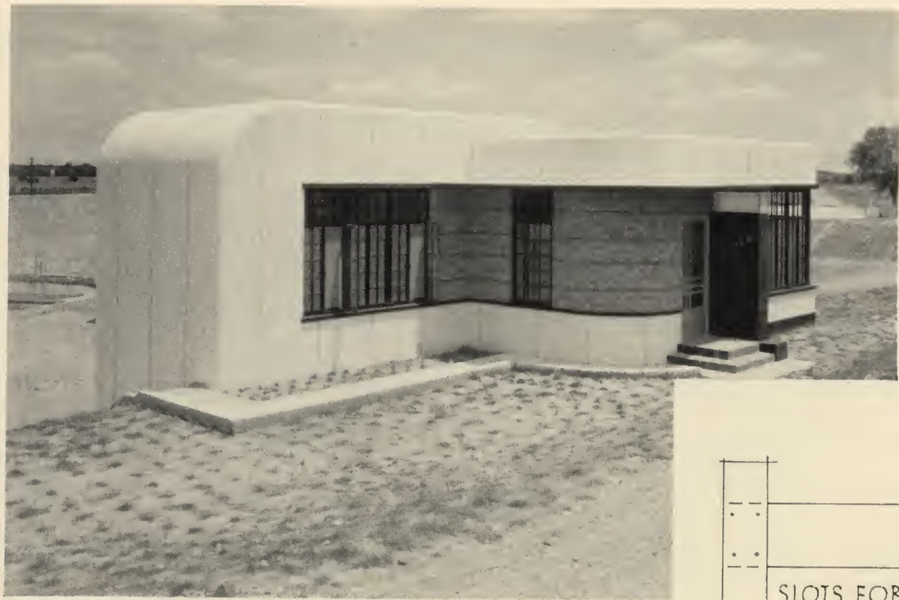
FORM DETAILS FOR WASTE MOLD ORNAMENT OVER DOORWAY AND PARAPET WALL ABOVE



FORM DETAIL FOR TOP OF CORNER PILASTERS



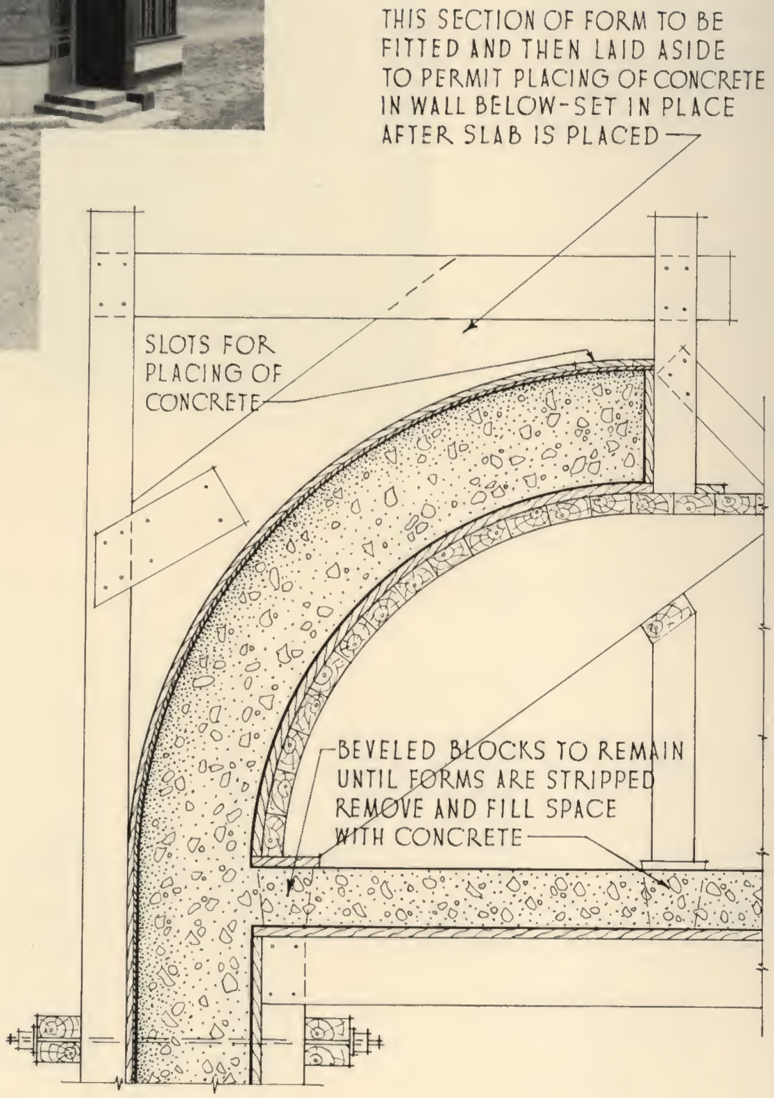
DETAIL OF FLUTINGS IN BOTH PILASTERS AND PARAPET



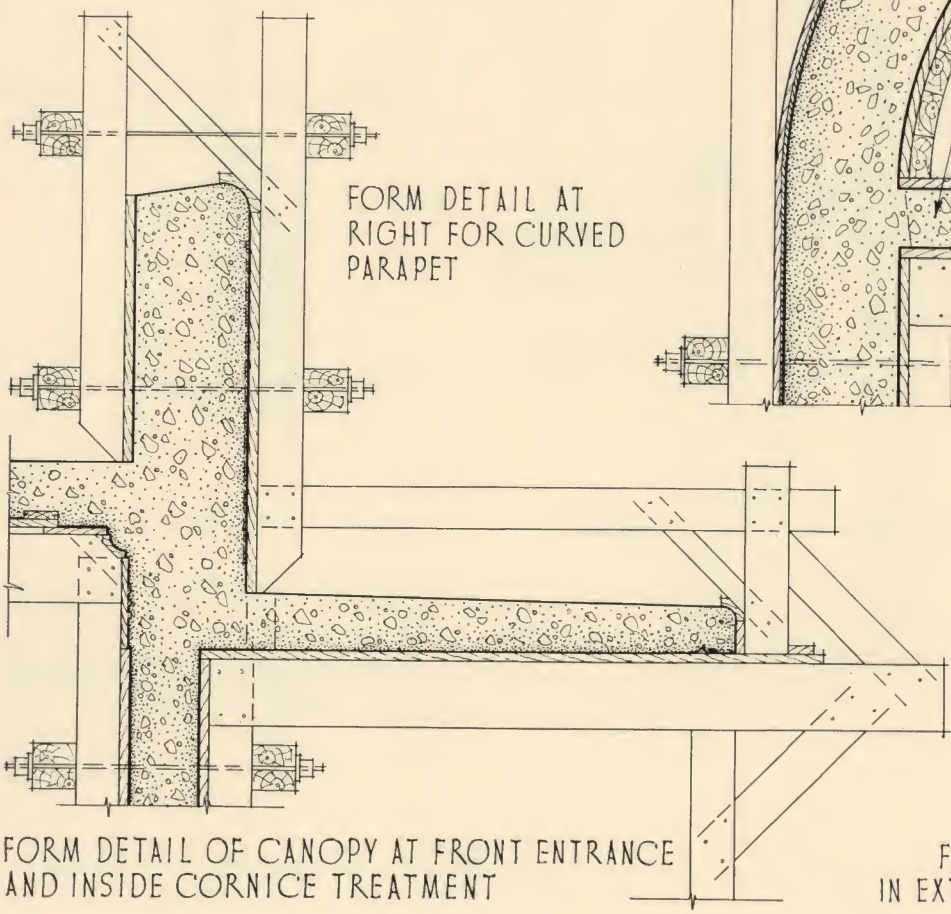
LABORATORY AND OFFICE SEWAGE TREATMENT PLANT

AUSTIN, TEXAS

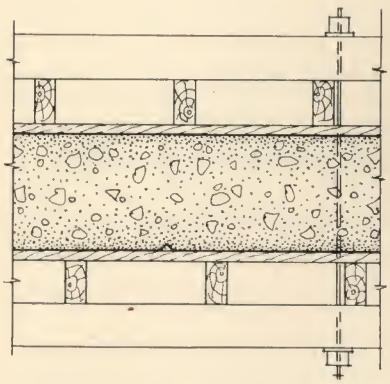
LOUIS C. PAGE AND G.S. MOORE, ARCHITECTS
BROWN AND ROOT, INC., CONTRACTOR



FORM DETAIL AT RIGHT FOR CURVED PARAPET



FORM DETAIL OF CANOPY AT FRONT ENTRANCE AND INSIDE CORNICE TREATMENT

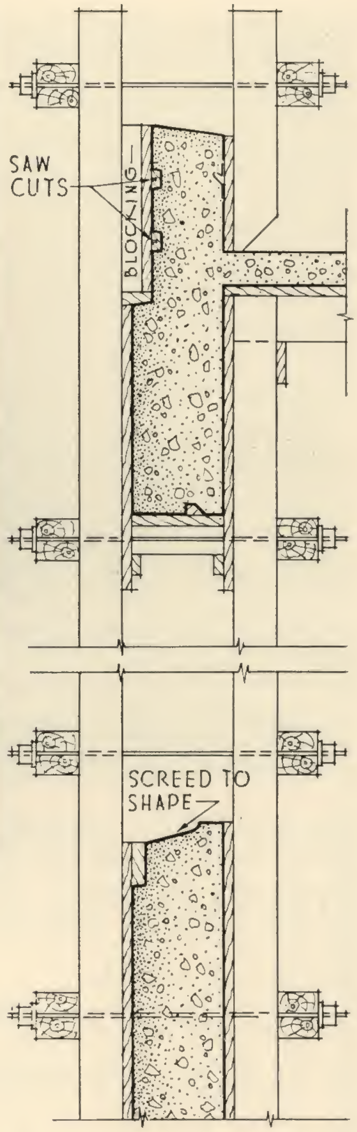


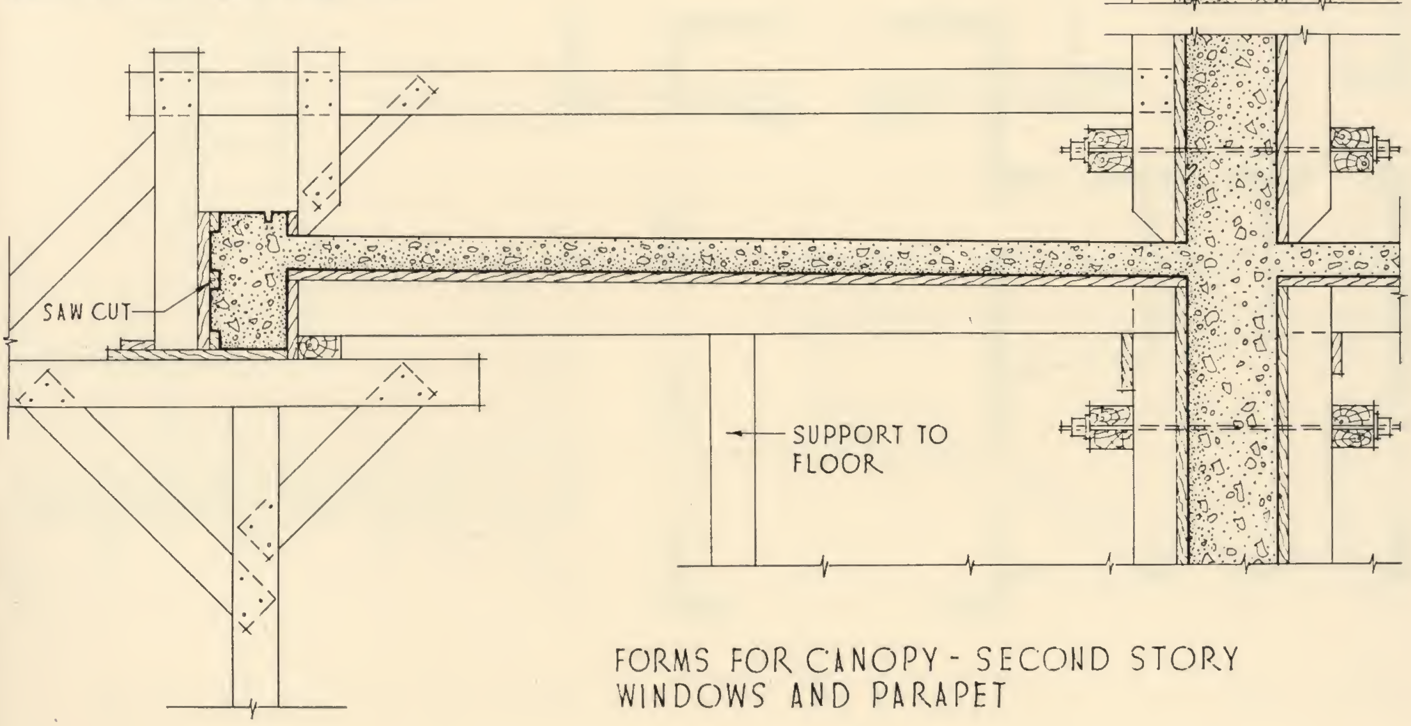
FORM DETAIL SHOWING V-SLOTS IN EXTERIOR SURFACE OF WALL

FIRE STATION

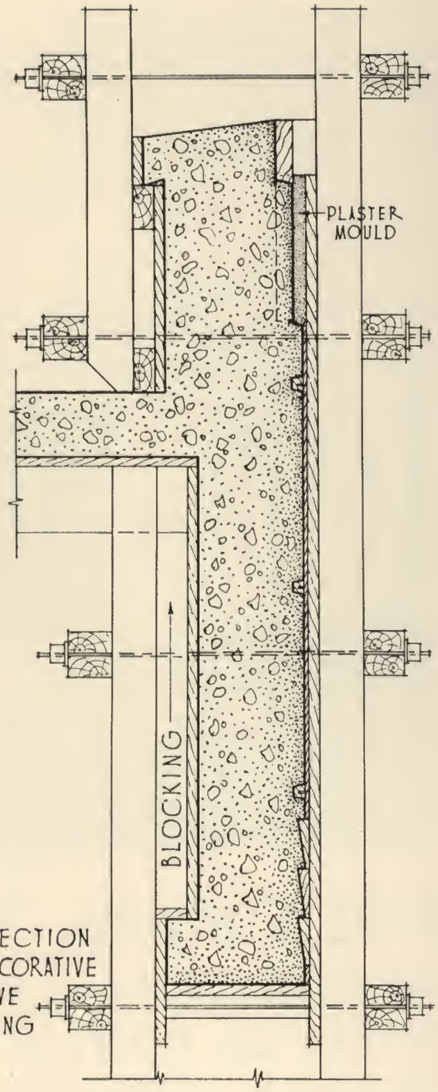
HOUSTON, TEXAS

J. G. McKENZIE, ENGINEER
BACE CORP., CONTRACTOR





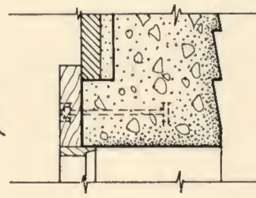
FORMS FOR CANOPY - SECOND STORY WINDOWS AND PARAPET



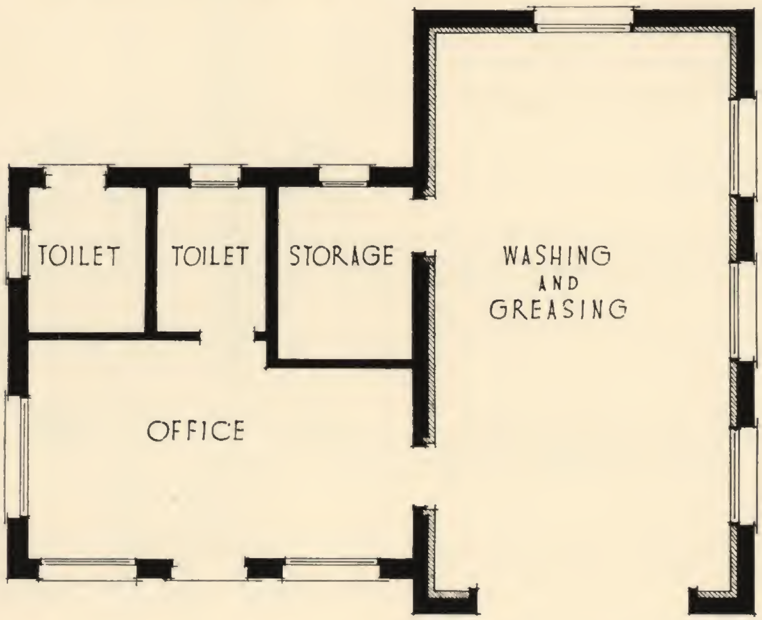
VERTICAL SECTION SHOWING DECORATIVE PANEL ABOVE DOOR OPENING

SERVICE STATION
CONTINENTAL OIL COMPANY
HOUSTON, TEXAS

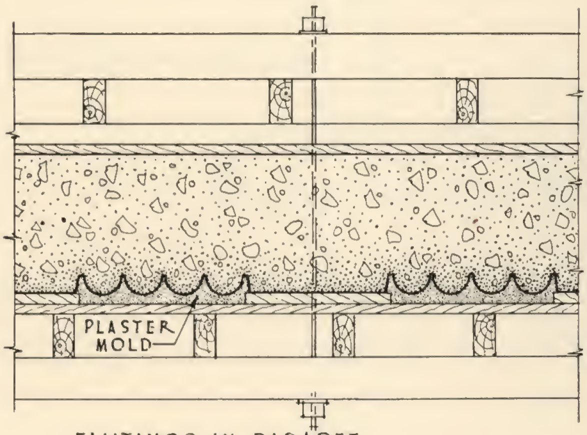
W. R. BROWN, ARCHITECT
L. R. ASHMORE, CONTRACTOR



DETAIL SHOWING INSTALLATION OF OVER HEAD DOOR

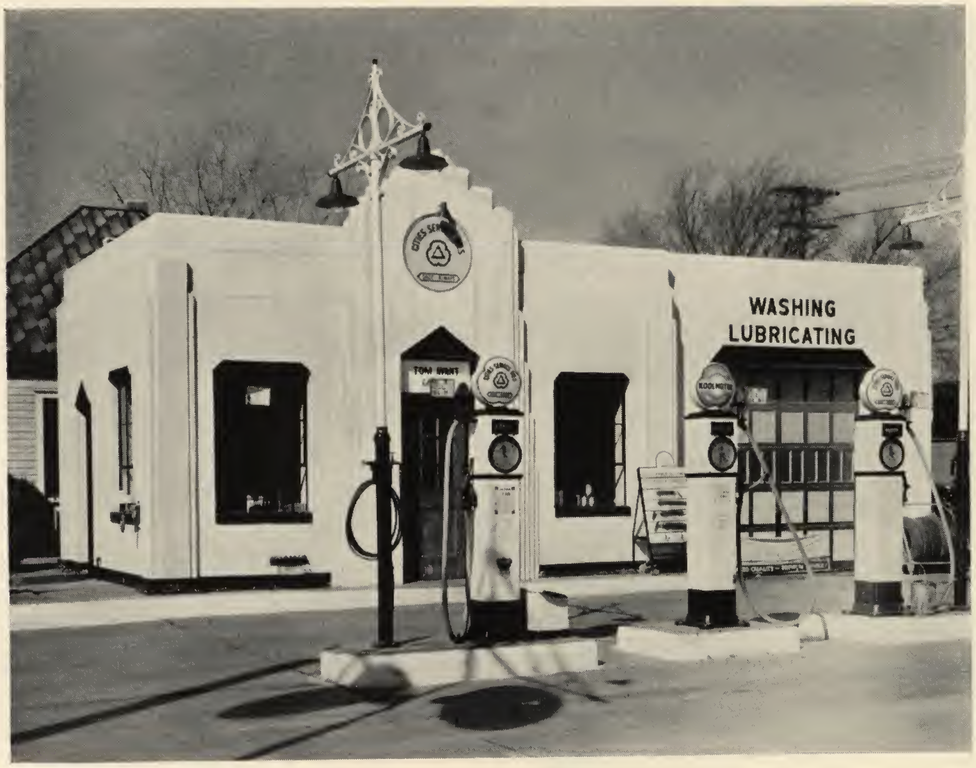


FLOOR PLAN



FLUTINGS IN PARAPET

FORM DETAIL ABOVE LARGE DOOR



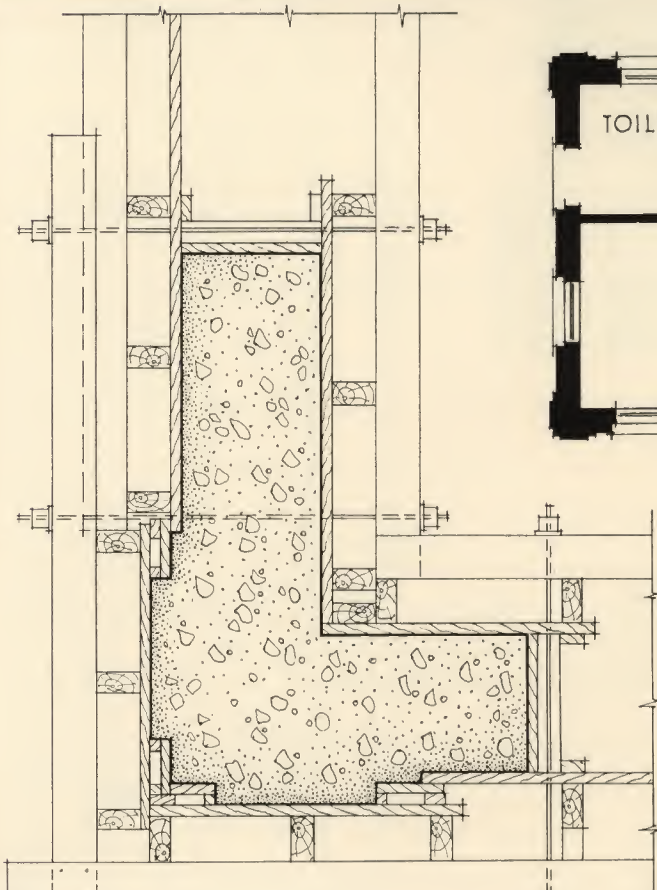
SERVICE STATION CITIES SERVICE OIL COMPANY

EL RENO, OKLA.

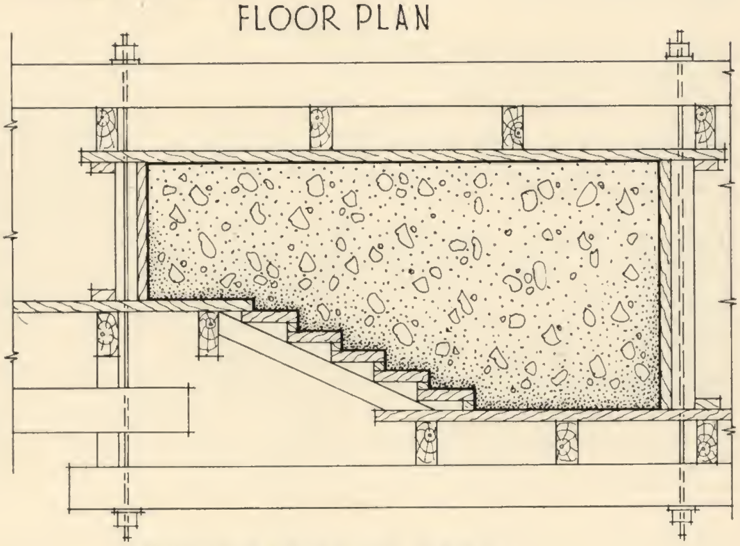
DESIGNED BY CITIES SERVICE OIL COMPANY

CONNELLY CONSTRUCTION CO. CONTRACTOR

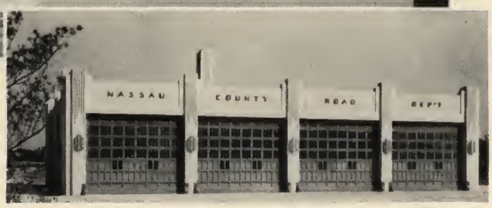
FLOOR PLAN



CORNER DETAIL



OFFICE ENTRANCE DETAIL

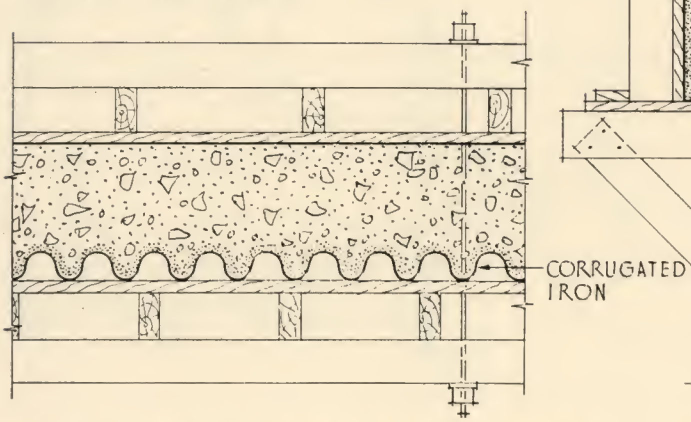


NASSAU CO. ROAD DEPT. GARAGE

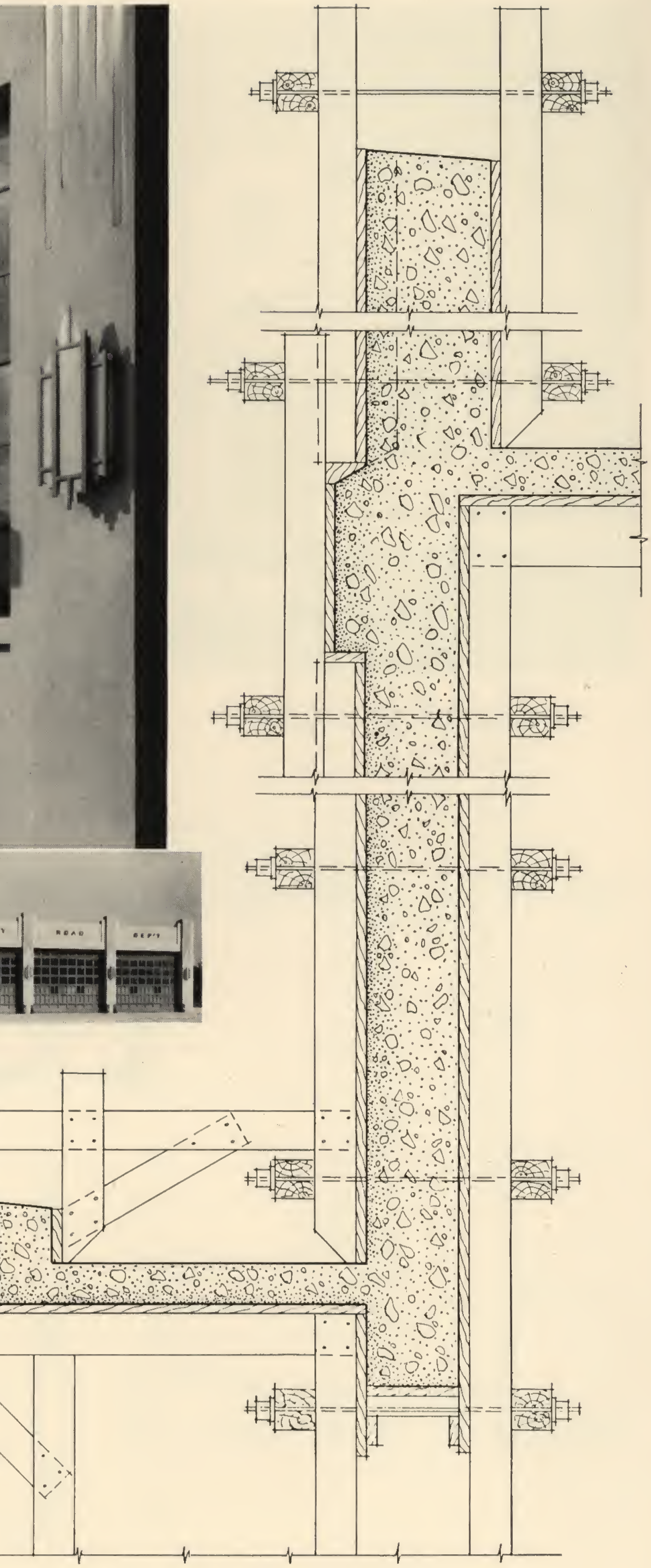
HEMPSTEAD, N.Y.

W.P.A. PROJECT

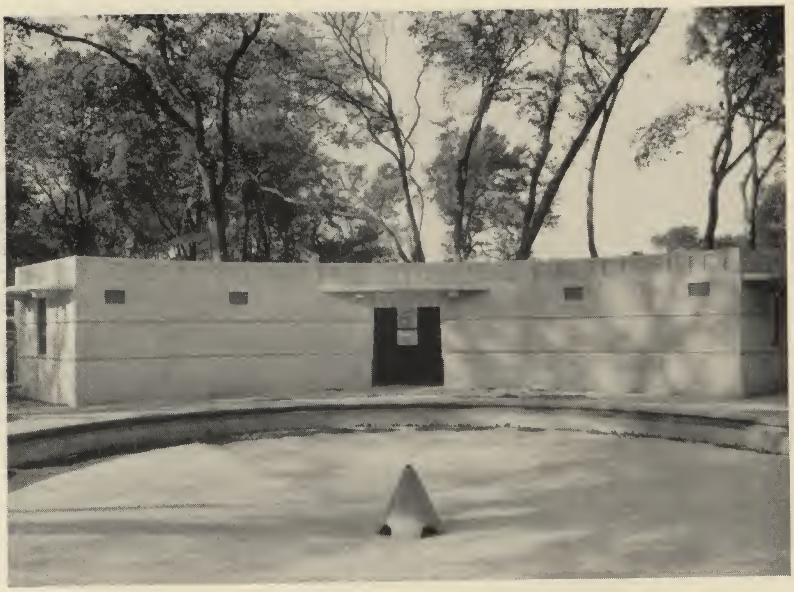
DESIGNED IN DEPARTMENT OF COUNTY ENGINEER

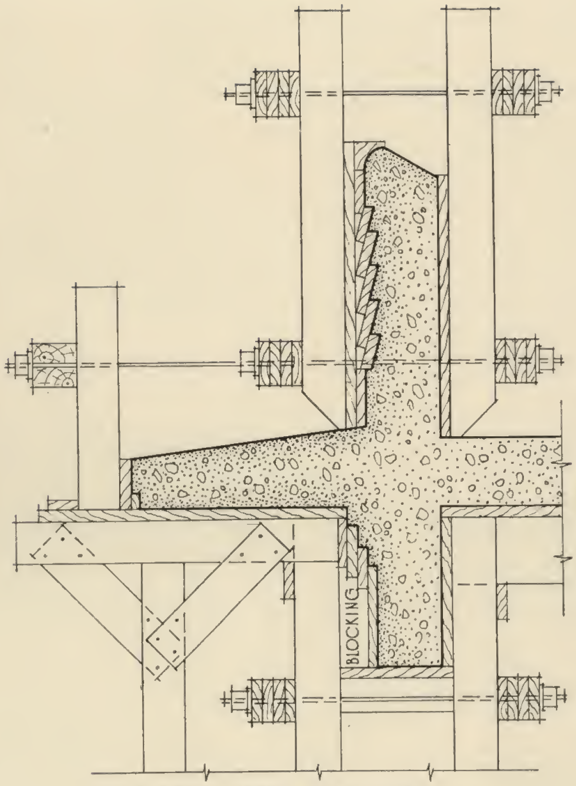


SECTION THRU PARAPET ABOVE OPENING



DETAIL OF CANOPY AND WALL ABOVE



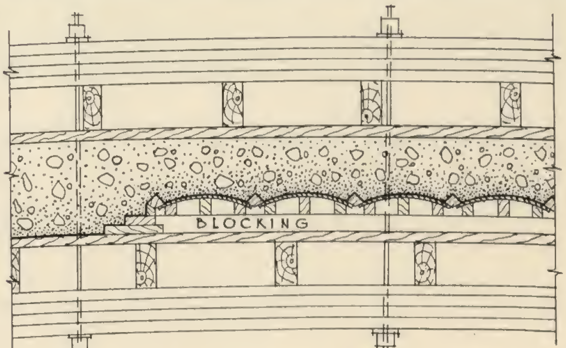


PARAPET AND CANOPY
OVER ENTRANCE

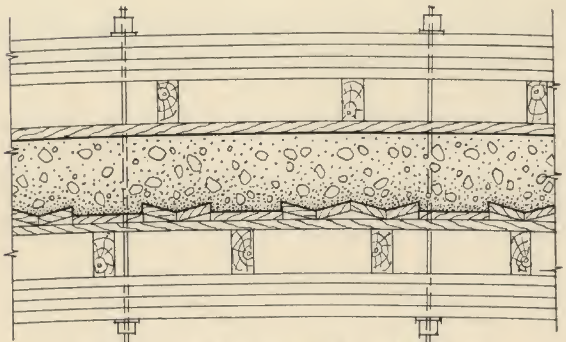
BATH HOUSE

SPRINGFIELD, MO.

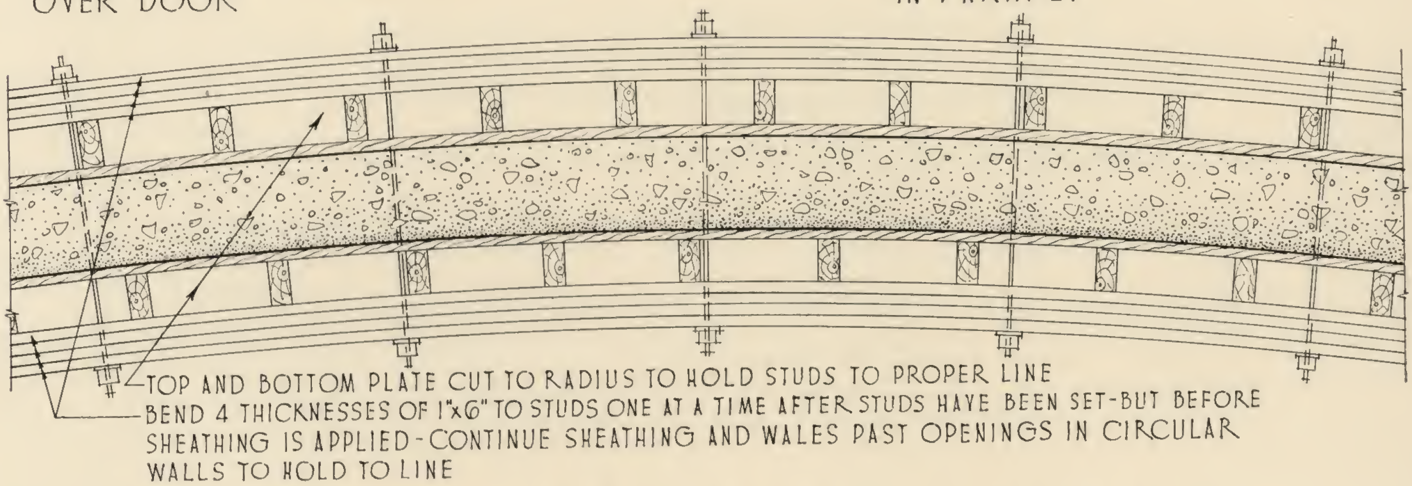
EARL HAWKINS, ARCHITECT
W. W. JOHNSON, ENGINEER AND CONTRACTOR



CROSS SECTION OF SPANDREL
OVER DOOR



CROSS SECTION OF PANELS
IN PARAPET



CROSS SECTION THROUGH TYPICAL WALL FORM

Fig. 33. Wolferman's—"Good Things to Eat," Kansas City, Mo., Edward W. Tanner, architect; Long Construction Co., contractor.

"In architecture, as in other arts, two considerations must be constantly kept in view; namely, the intention, and the matter used to express that intention."—Vitruvius

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